Appendix C
Onsite Sewage Disposal Systems: Evaluation of Treatment Alternatives and Costs

Onsite Sewage Disposal Systems: Evaluation of Treatment Alternatives and Costs

PREPARED FOR: Anne Arundel County

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COPIES: Maryland Department of the Environment

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Attachments

Executive Summary

Anne Arundel County, Maryland, is conducting a countywide evaluation of service options for properties with onsite sewage disposal systems (OSDS, commonly referred to as septic systems). The overall goal of this effort is develop a forward-looking framework to enable the County to implement a program for the long-term management of onsite systems in the County pursuant to achieving the nitrogen reduction goals for the Chesapeake Bay. The purpose of this technical memorandum (TM) is to present planning-level cost estimates for potential cluster community wastewater systems, enhanced onsite septic systems, and potential sewer extension projects to connect existing areas on septic to existing sewer service areas (SSAs).

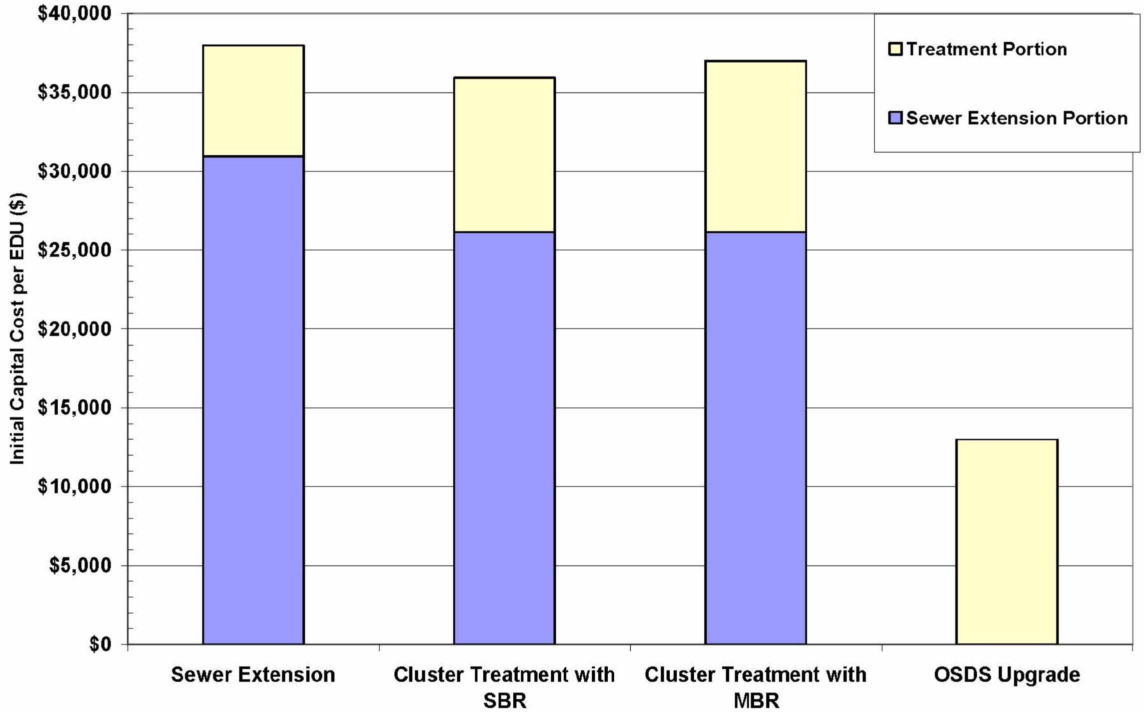
These treatment approaches were evaluated with respect to their life-cycle costs and removal efficiency and to provide baseline planning information for developing a county-wide treatment strategy in the final phase of the project to follow. Lastly, several key issues were identified in terms of present directions in nutrient management policy (e.g., eligibility of Watershed Restoration Funds to support more-effective treatment approaches) that may have significant bearing on the formulation of a countywide OSDS treatment strategy.

Detailed schematic designs were completed for 10 study areas that represent 5,654 acres of Anne Arundel County that were served by onsite systems. From these designs, detailed capital and operation and maintenance (O&M) cost estimates were prepared using a life-cycle cost module. This module was applied to provide a uniform evaluation of the effectiveness of three treatment approaches:

1. Extension of the County collection system to serve the OSDS communities
2. Provision of a local collection system and a cluster treatment facility for each community
3. Upgrading the existing OSDS to provided enhanced nitrogen removal

The unit costs of each of treatment approach are presented in Figures E-1 and E-2 as an Equivalent Uniform Annual Cost (EUAC) and an initial capital cost respectively. The costs were computed using a 5 percent discount rate and a 4 percent inflation factor. These graphs indicate that OSDS system upgrades are least costly from an initial capital investment standpoint, but are similar in cost over the long term when O&M, service life, inflation, and energy costs are accounted for. It should also be noted that the OSDS upgrade alternative assumed that drain field replacement or rehabilitation costs would be incurred in the initial capital cost of the upgrade. Figure E-3 provides a breakdown of the individual components of the EUAC costs. These costs have incorporated the recent Maryland energy cost increases through May 2007.

FIGURE E-1
Initial Capital Cost per Equivalent Dwelling Unit (EDU) for Each Treatment Alternative with additional Water Reclamation Facility (WRF) Capacity shown



Tables E-1 and E-2 summarize the costs to provide treatment to all OSDS in the County by priority area, as reported in TM-1: Identification, Categorization, and Prioritization Study. The unit costs of treatment were extrapolated on a countywide basis, using the average of the costs of each treatment alternative for the 10 representative communities. These tables indicate that the total program cost for the OSDS upgrades over the long term could range from $527million to $1.6 billion. Although it is unrealistic for every OSDS to require a treatment upgrade, these cost figures underscore the importance of selecting a long-term treatment method that will provide sustainable nitrogen reductions.

FIGURE E-2
EUAC per EDU for Each Treatment Alternative with additional WRF capacity shown

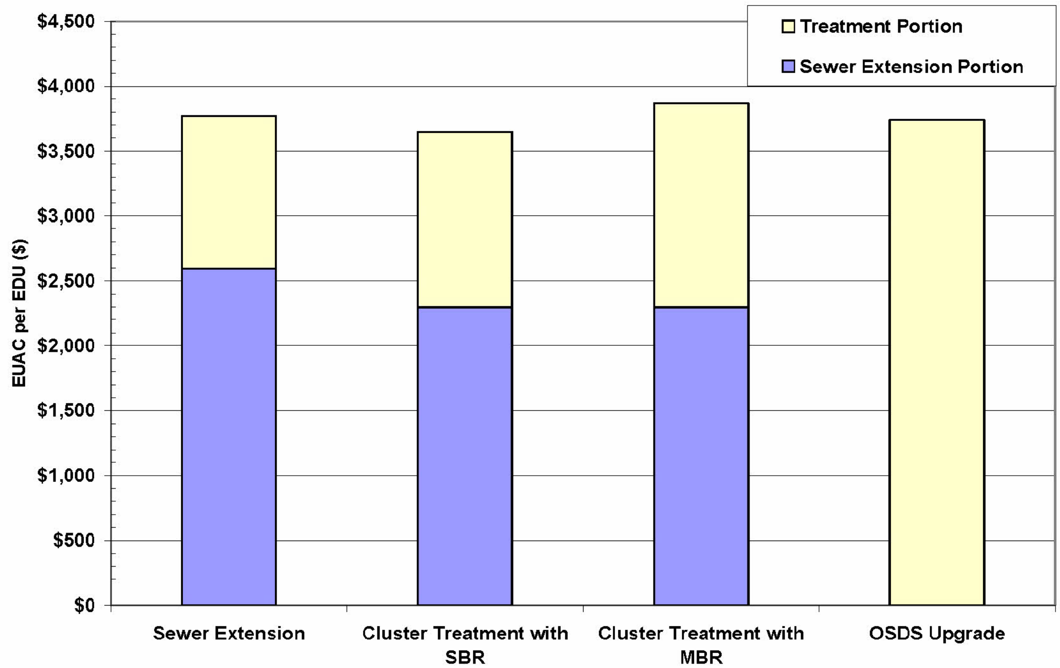


FIGURE E-3
EUAC per EDU for Each Treatment Alternative with Component Cost Breakdown

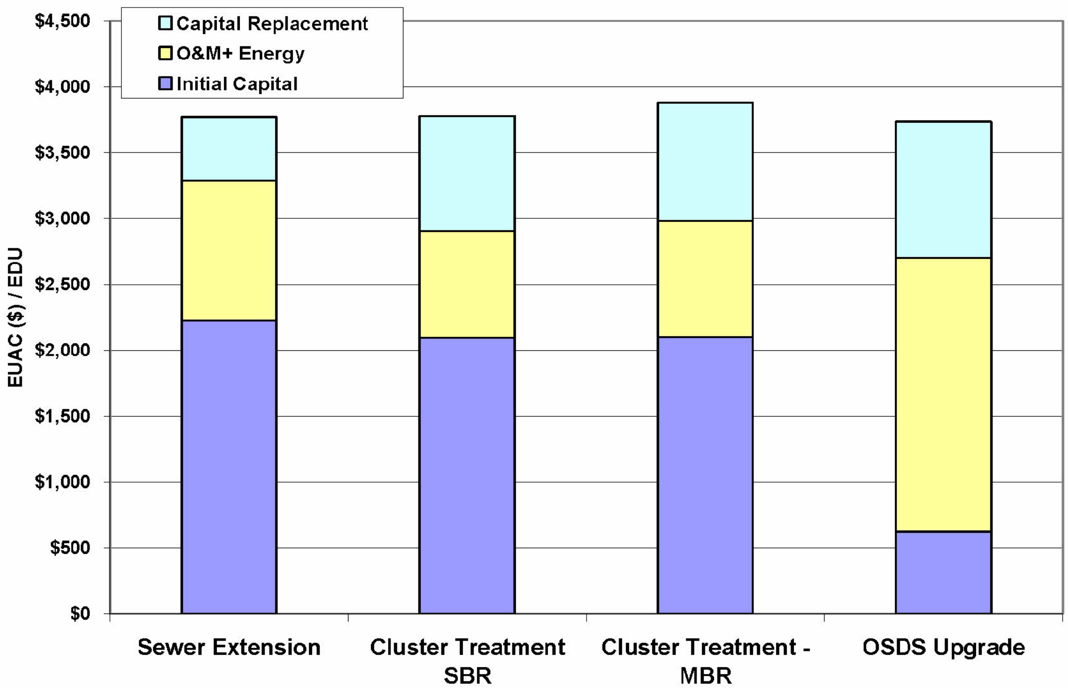


TABLE E-1
Countywide Initial Capital Costs by OSDS Priority Rank

				Initial Capital ($M)			
Priority Score Category	**EDUs**	**Total Nitrogen (lb/yr)**	**Percent *Unit Cost per EDU***	**Sewer Extension**	**Sewer Extension w/ addt'l treatment**	**Cluster Treatment**	**OSDS Upgrade**
			Unit Cost per EDU	*$27,963*	*$38,000*	*$36,203*	*$13,000*
1.0-1.5	13,186	225,869	26%	$369	$501	$477	$171
1.5-2.0	5,546	110,505	14%	$155	$211	$201	$72
2.0-2.5	5,696	133,136	18%	$159	$216	$206	$74
2.5-3.0	7,403	179,265	18%	$207	$281	$268	$96
3.0-3.5	4,383	111,573	11%	$123	$167	$159	$57
3.5-4.0	2,218	62,878	6%	$62	$84	$80	$29
4.0-4.5	1,534	41,433	4%	$43	$58	$56	$20
4.5-5.0	578	16,340	2%	$16	$22	$21	$8
Grand Total	**40,544**	**881,000**	**100%**	**$1,134**	**$1,541**	**$1,468**	**$527**

TABLE E-1
Countywide Initial Capital Costs by OSDS Priority Rank

				Initial Capital ($M)			
Priority Score Category	**EDUs**	**Total Nitrogen (lb/yr)**	**Percent *Unit Cost per EDU***	**Sewer Extension**	**Sewer Extension w/ addt'l treatment**	**Cluster Treatment**	**OSDS Upgrade**
			Unit Cost per EDU	*$27,963*	*$38,000*	*$36,203*	*$13,000*
1.0-1.5	13,186	225,869	26%	$369	$501	$477	$171

TABLE E-2
Countywide Equivalent Uniform Annual Cost (EUAC) by OSDS Priority Rank

				EUAC ($M)			
Priority Score Category	**EDUs**	**Total Nitrogen (lb/yr)**	**Percent *Unit Cost per EDU***	**Sewer Extension**	**Sewer Extension w/ addt'l treatment**	**Cluster Treatment**	**OSDS Upgrade**
			Unit Cost per EDU	*$2,607*	*$3,780*	*$3,550*	*$3750*
1.0-1.5	13,186	225,869	26%	$34.4	$49.8	$46.8	$49.4
1.5-2.0	5,546	110,505	14%	$14.5	$21.0	$19.7	$20.8
2.0-2.5	5,696	133,136	18%	$14.8	$21.5	$20.2	$21.4
2.5-3.0	7,403	179,265	18%	$19.3	$28.0	$26.3	$27.8
3.0-3.5	4,383	111,573	11%	$11.4	$16.6	$15.6	$16.4
3.5-4.0	2,218	62,878	6%	$5.8	$8.4	$7.9	$8.3
4.0-4.5	1,534	41,433	4%	$4.0	$5.8	$5.4	$5.8
4.5-5.0	578	16,340	2%	$1.51	$2.18	$2.05	$2.17
Grand Total	**40,544**	**881,000**	**100%**	**$106**	**$153**	**$144**	**$152**

Policy Issues

During the analysis of the technical performance requirements, applicability, and cost of the treatment alternatives, several policy issues emerged that are important to consider in the selection of the future treatment approaches and implementation policies for the County's onsite systems. These issues generally fell into three categories:

- Permitting issues, including nutrient load caps and credits
- Chesapeake Bay Restoration Fund eligibility
- Compatibility with the County Comprehensive Plan and growth management

Permitting Issues

The assumptions for estimating nitrogen delivery to the County's receiving waters was shown to vary widely as the regulatory policy has evolved. This variance was found to have a significant bearing on both the load contributed by onsite systems in relation to other sources and ultimately affects the waste load allocation policy and "hook-up" credits that could be applied. Cluster treatment systems proved to be a cost-effective treatment technology, especially for communities above a size and density threshold. At present, it is unclear how this type of facility would be treated by MDE in the context of their evolving "bubble" permit framework.

This TM also discusses the need to create alternate and site-specific treatment approaches for areas with the following characteristics:

- Poor soil infiltration and high groundwater table
- Heath Department problem areas
- Long distance to sewer
- No direct discharge option because of shellfish restrictions

For example, regulatory and permitting implications could arise in the case where a membrane bioreactor (MBR)-based cluster treatment facility is the best option for areas with poor soils and a long distance to existing sewer service. In non-shellfish waters, a direct discharge option could be the most cost-effective treatment alternative, but it is unclear if permits would be granted under these cases. Similarly, cases will arise where sewer extension will be the most cost-effective treatment approach in Resource Conservation Areas and areas not presently designated for sewer service.

Given that challenging circumstances will exist in many cases, Anne Arundel County asked that innovative options be explored. The Hunters Harbor area exhibits all of the above-mentioned challenges and was evaluated for the potential use of wetland discharge and spray irrigation as the ultimate disposal option. The evaluation included the assumption that a cluster treatment facility would be employed and be capable of achieving effluent total nitrogen (TN) concentration in the 3-8mg/L range. Spray irrigation is a practice that is currently supported in the MDE *Guidelines for Land Treatment of Municipal Wastewaters*, and discharge to a treatment wetland could also be a viable option in certain cases. Using these options in combination with an MBR cluster treatment facility could also result in additional nutrient uptake (credits) that could be applied in the countywide strategy.

Nitrogen Delivery

A meeting was held with MDE to confirm current policy regarding nitrogen loading assumptions to be used for programs to comply with the nitrogen reduction requirements. MDE has provided the following statewide average septic load to surface water:

Septic Load = (People per Household) x (Loading rate in pounds TN per person / yr) x (Delivery Ratio) = 14.8 lbs TN / septic system per year where:

- People per Household = 2.6 persons/EDU
- Pounds TN per person / yr = 9.5 lbs/person/yr TN at edge of septic drain field (based on 78 gpcd at 40 mg/L TN)
- Delivery Ratio = 0.60

At a meeting on May 15, 2007, MDE provided their revised guidelines for estimating nitrogen delivery from onsite systems. The approach, as shown in Figure E-4, allocates a delivery as a function of the distance to receiving water according to the following assumptions:

- 80 percent in critical areas (i.e., within 1,000 feet of tidal surface waters)
- 50 percent for areas outside of critical areas, but within 1,000 feet of surface waters (i.e. non-tidal surface waters)
- 30 percent all others

Application of this new framework resulted in a 38 percent reduction in the total estimated load from onsite systems—from 1.21 million pounds as calculated in the base case of TM 1 to 881,000 pounds per year under the new MDE assumptions. When compared to the cumulative number of OSDS within this range, it is readily apparent that the delivery ratio assumption within the first 300 feet of receiving water is critical to the overall management strategy for the OSDS systems. An expanded scientific basis for the delivery ratio assumptions should be sought. Table E-3 summarizes the nitrogen loads that result from the delivery ratio approaches considered to date and compares the total load with that contributed by the wastewater reclamation facilities (WRFs) after conversion to Enhanced Nitrogen Removal (ENR).

FIGURE E-4
Base Case Nitrogen Delivery Ratio Assumptions from TM1 and from MDE Policy as of 5/15/2007.

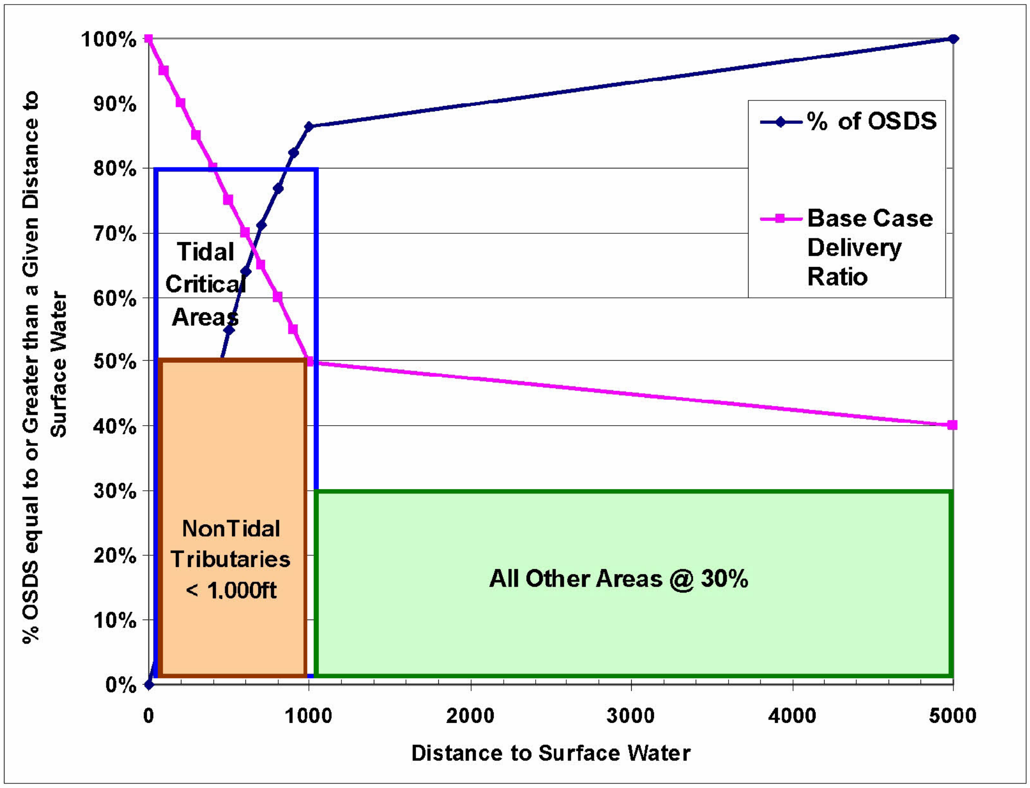


TABLE E-3
Comparison of WRF and Septic Loads

WRF Loads	TN (lbs/yr)	TN (lbs/yr) after ENR upgrades
2005 WRF Load	747,865	631,854
Estimated Septic Load	**TN (lbs/yr)**	**TN (lbs/yr) after OSDS upgrades**
Base Case Task 1 TM (Figure E-4)	1,241,400	624,330
60% Uniform Delivery	959,000	482,328
Revised MDE Delivery (80/50/30)	881,000	443,221

Cost-effectiveness of denitrifying upgrades versus hookup to sewer

The overall cost-effectiveness of each treatment approach in reducing nitrogen loads delivered to area receiving waters was analyzed on a unit cost per pound removal basis. The MDE 80/50/30 delivery ratio approach was applied to the effluent concentration for each treatment approach and applied to each OSDS in the county. The effluent concentrations were assumed to be 3 mg/L for the sewer extension alternative to reflect upgrading the WRFs to ENR. The MBR-based cluster treatment facilities used in the cost analysis were designed provide an effluent with 3 mg/L TN. The sequencing batch reactor (SBR) cluster systems would provide 8 mg/L to be consistent with MDE requirements for all treatment facilities above 5,000 gallons per day (gpd). The OSDS denitrification upgrades were estimated to provide 20 mg/L TN per MDE policy. The total cumulative delivered load and the total load reduction achievable are summarized in Table E-4. The achievable reductions from this table were used to translate the average treatment cost for each alternative to a cost per pound removed. This is illustrated in Figures E-5 and E-6, along with the total achievable TN reduction.

TABLE E-4
Comparison Of Treatment Alternatives By Effluent Concentration, Delivered Load, And Achievable Countywide Reduction

	Sewer Extension and WRF	Cluster Treatment with SBR and Land Application	Cluster Treatment with MBR and Direct Discharge	OSDS Upgrade
Effluent N Concentration (mg/L)	3	8	3	20
Delivered TN	119,640	323,581	119,640	443,221
Achievable TN Reduction	761,360	557,419	761,360	437,779
Initial Capital Cost $/LB TN Removed	$2,030	$2,621	$1,977	$1,208
EUAC $/LB TN Removed	$201	$266	$207	$347

Note - Load estimates based on current MDE delivery ratio assumption - 80% for OSDS in Critical Area, 50% for OSDS within 1000' of receiving water, 30% for all other OSDS

This analysis indicated that on a per-unit removal basis, sewer extensions and cluster treatment approaches are more cost effective and are capable of obtaining a higher level of overall nitrogen removal than OSDS upgrades.

FIGURE E-5
Estimated Nitrogen Load Reduction Achievable by Treatment Technology and Total Initial Capital Cost per lb. of Nitrogen Removed

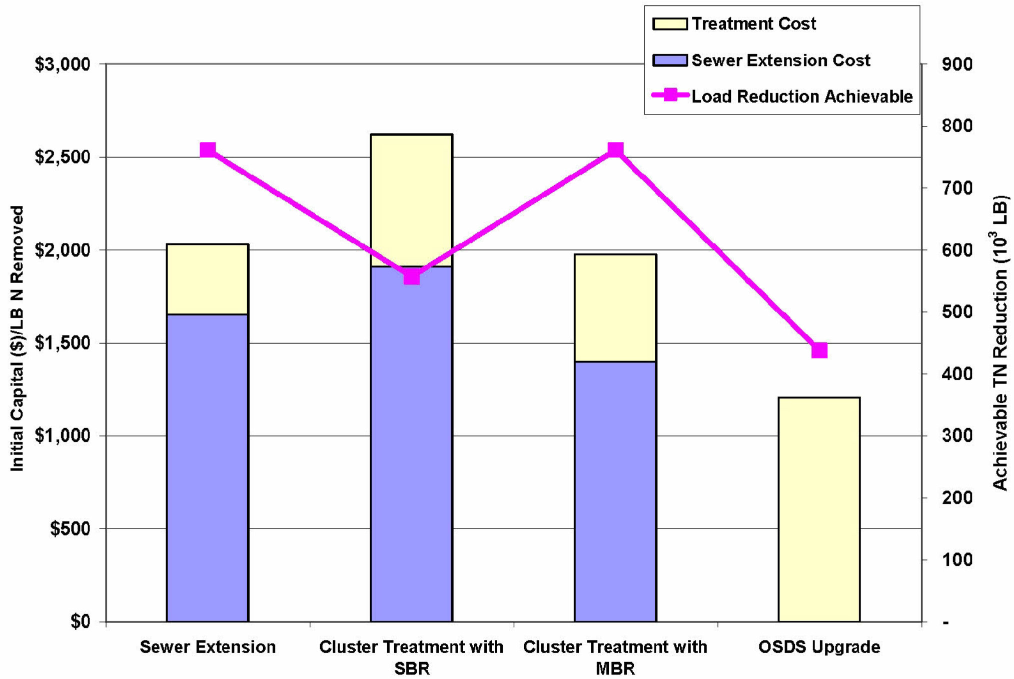
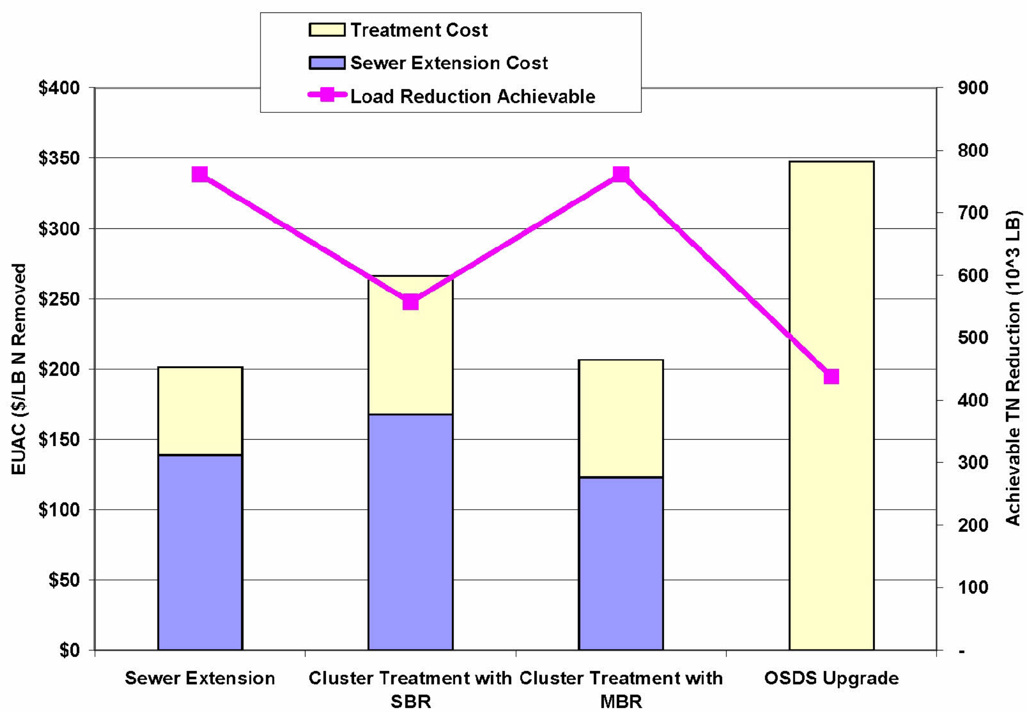


FIGURE E-6
Estimated Nitrogen Load Reduction Achievable by Treatment Technology and Equivalent Uniform Annual Cost per lb. of Nitrogen Removed



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Chesapeake Bay Restoration Fund Eligibility

The cost-benefit analysis indicated that cluster treatment and sewer extension alternatives are more effective in terms of life- cycle costs and nitrogen removal effectiveness. Presently, there is no conduit for Chesapeake Bay Restoration Funds to be used for connecting onsite systems to public sewers or to effective decentralized treatment practices such as cluster treatment facilities and treatment wetlands. Table E-5 presents a basic credit scenario based on the revised MDE loading approach. Providing a sewer extension or cluster treatment facility to an existing OSDS area would result in a TN credit of 8 pounds/year.

TABLE E-5
Summary of Conceptual Credits

	TN (lb/yr)	Delivered TN Load (lb/OSDS)
Existing Condition Estimated TN to Receiving Waters per OSDS (lb/yr) *	881,000	21.7
Delivered Load per OSDS converted to denitrification at 20 mg/L effluent quality (lb/yr)	443,221	10.9
Load per OSDS connected to sewer and WRF with ENR or MBR Cluster treatment facility (lb/yr)	119,640	2.9
Load Reduction beyond tributary strategy requirement, per OSDS connected to sewer or MBR cluster treatment (lb/yr)	323,581	8.0

* Current MDE delivery ratios as 80% for OSDS in Critical Area, 50% for OSDS within 1000' of receiving water, 30% for all other OSDS

Compatibility with the Comprehensive Plan and Growth Management

Many of the OSDS systems are located in the Resource Conservation Area or in areas where sewer service was not previously planned for in the County's comprehensive plan, potentially limiting the application of the most effective treatment technology. Growth management is an important issue to be considered in the overall nutrient management strategy for the County. It should be noted that the costs to provide treatment via sewer extensions and cluster treatment were sized to handle the ultimate build-out scenario in terms of capacity. Although the technologies were all very similar in terms of their annual life-cycle costs, they differed significantly in terms of their ability to provide nitrogen removal and their ability to accommodate growth with minimal additional nitrogen production. These issues will be considered in the next project phase.

TABLE E-6
Countywide Estimates of Initial Capital Costs Based on Average Cost / EDU

		Countywide Initial Capital Cost ($M)		
Planned Sewer Service Type	**EDUs *per EDU***	**Sewer Extension**	**Cluster Treatment**	**OSDS Upgrade**
Existing Service	1,881	$71	$68	$24
Future Service	8,322	$316	$301	$108
No Public Service	23,041	$876	$834	$300
Other	18	$1	$1	$0
Park	22	$1	$1	$0
Planned Service	5,676	$216	$205	$74
Resource Conservation Area	1,584	$60	$57	$21
(blank)	140	$5	$5	$2
Grand Total	40,684	$1,546	$1,473	$529

*Includes $7050 capital cost/EDU, and $385/EDU/yr
**Based on least expensive cluster treatment option

TABLE E-7
Countywide Estimates of EUAC Based on Average Cost / EDU

		EUAC ($M)		
Planned Sewer Service Type	**EDUs *per EDU***	**Sewer Extension**	**Cluster Treatment**	**OSDS Upgrade**
Existing Service	1,881	$7	$7	$7
Future Service	8,322	$31	$30	$31
No Public Service	23,041	$87	$82	$86
Other	18	$0	$0	$0
Park	22	$0	$0	$0
Planned Service	5,676	$21	$20	$21
Resource Conservation Area	1,584	$6	$6	$6
(blank)	140	$1	$0	$1
Grand Total	**40,684**	**$154**	**$144**	**$153**

*Includes $7050 capital cost/EDU, and $385/EDU/yr
**Based on least expensive cluster treatment option

Purpose and Background

Anne Arundel County, Maryland, is conducting a countywide evaluation of service options for properties with onsite sewage disposal systems (OSDS, commonly referred to as septic systems). The overall goal of this effort is to assist the County in preparing a treatment strategy to reduce nitrogen loads from onsite systems that are delivered to Chesapeake Bay. A second goal of this effort is to examine funding options, including the Chesapeake Bay Watershed Restoration Fund (the "Flush Fee") to support implementation of the strategy. The project is being conducted in four tasks, as follows:

- **Task 1 –** Identifying, Categorizing and Prioritizing Septic Systems
- **Task 2 –** Preliminary Cost Analysis of Onsite Septic System Upgrades and Cluster Community Wastewater Systems
- **Task 3 –** Preliminary Cost Analysis of Sewer System Extensions
- **Task 4 –** Implementation Plan and Final Report

Task 1 was completed on January 26, 2007. This TM documents the results of Tasks 2 and 3 of this study.

The purpose of Task 2 was to develop planning-level cost estimates (adjusted to 2007) for potential cluster community wastewater systems and enhanced onsite septic systems.

The purpose of Task 3 was to develop planning-level cost estimates for potential sewer extension projects (adjusted to 2007) within existing SSAs to include options to connect existing areas on septic to sewer. Task 4 will document the analysis and recommendations developed over the course of Tasks 1 through 3 in a final Onsite Sewage Disposal System Facilities Plan, which summarizes alternatives considered and the recommended alternatives for implementation on a countywide basis. The treatment alternatives and costs developed in Task 2 and 3 will be evaluated geospatially, and the recommended alternatives for cluster wastewater facilities, enhanced OSDS, and sewer system extensions will be summarized with respect to OSDS management areas, watersheds, and sewer planning category. The plan will be developed for the 20- year planning horizon adopted for the Comprehensive Sewer Strategic Plan (CSSP).

Methodology

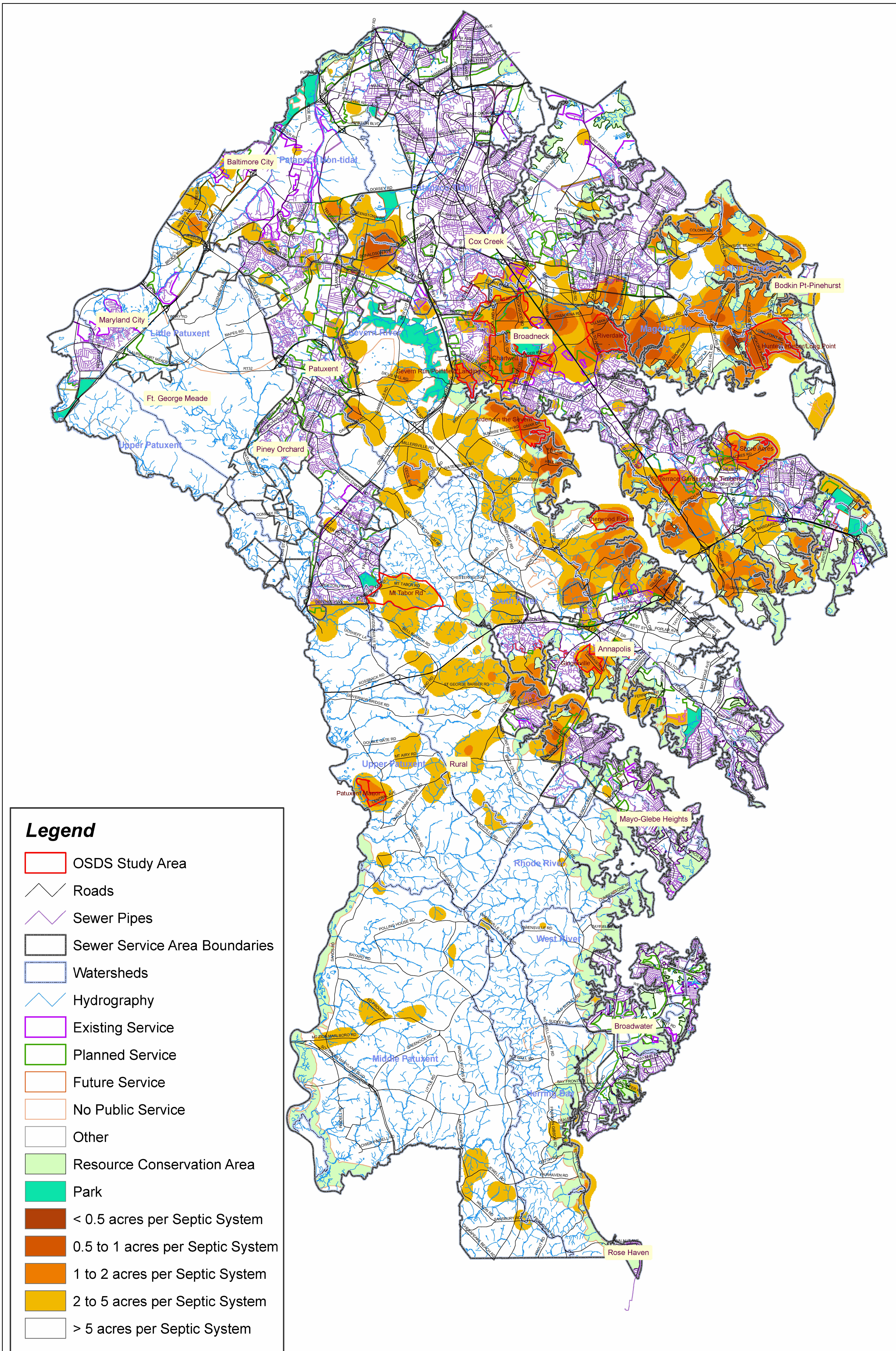
Task 1 identified and characterized OSDS throughout the county, which became subject to the Flush Fee starting in early 2006. Figure 1 shows the location and density ranges of the 40,684 properties that have an OSDS, according the most recent County database, out of more than 193,346 properties countywide. The overall approach for this phase of the project was to develop costs for sewer extension and for cluster-type community wastewater treatment systems for a set of representative example communities served exclusively by septic tanks. The cost estimates for each study areas were then analyzed to determine if cost curves or relationships could be established for extrapolating the costs for each potential OSDS management approach. These representative estimates of the treatment system costs were then applied on a countywide basis so that implementation issues and nitrogen load implications could be evaluated in relation to the Maryland Department of Natural Resources (MDNR) Tributary Strategies. Nitrogen load estimates were then developed for each treatment option and combined with the cost data to determine the overall efficacy of each treatment alternative in terms of managing nitrogen loads from the county OSDS.

The overall approach was applied using the following general task progression:

1. Identify representative study areas
2. Develop flow projections for each study area
3. Design the sewer extension approach and calculate the cost for each area (Harms & Associates)
4. Design the cluster treatment approach and calculate the cost for each area, which relied in part on the sewer extension design to transport flow to the cluster treatment facility (Stearns & Wheler, LLC)
5. Evaluate cost relationships
6. Project countywide OSDS flows
7. Project countywide treatment costs for each alternative
8. Project countywide nitrogen load implications associated with each treatment option

Study Area Delineation

Figure 1 also shows the locations of the 10 representative OSDS study areas that were analyzed in more detail. The example areas were defined to incorporate a range of factors that would be potentially relevant in projecting the cost implications of the various treatment options on a countywide basis. These factors included OSDS density, distance to sewer, service area type, and overall size of service area.



0 2 4 Miles

Figure 1. Onsite Sewage Disposal System (OSDS) Density and Study Areas

CH2MHILL

May 14, 2006

Flow Projections

Two sets of flow projections were completed for this study:

1. Estimates of the ultimate flow for each representative community so that sewer facilities and treatment alternatives and their respective costs would reflect the future level of service they would need to provide.

2. Wastewater flow projections for all existing septic systems in each SSA by applying the County-specified flow factor of 250 gal/OSDS/day[1] so that costs could be readily extrapolated to the entire county.

Flows were projected for each study area using the County flow projection tool developed for the Comprehensive Sewer Strategic Plan (CSSP). The tool was modified to account for residential and non-residential OSDS within the study area and also accounted for infill development that would likely occur over the planning horizon. So that the treatment system would be appropriately sized, it was also assumed that if sewer extensions or a cluster facility was provided, all future development would be allowed to hook up to the system. The number of OSDS in each study area were accounted for using the standard flow factor of 250 gal/OSDS/day and combined with projected flows for the year 2030. The flow projections are summarized in Table 1.

TABLE 1
OSDS Study Area Summary with Flow Projections for Existing OSDS and Ultimate Flow

Study Area	Area (acres)	# Existing OSDS	OSDS / Acre	OSDS Flow (gpd)	Future Development Flows (gpd)	Ultimate Flow (gpd)	Ultimate Flow (EDUs)
Gingerville	219	238	1.09	61,016	24,672	85,688	343
Terrace Gardens	146	181	1.24	50,750	79,208	129,958	520
Arden on the Severn	282	471	1.67	117,750	45,826	163,576	654
Chartwell	1,751	1,479	0.84	369,000	351,068	720,068	2,880
Hunters Harbor - Long Point	803	1,094	1.36	278,750	173,273	452,023	1,808
Mt. Tabor Rd	944	338	0.36	84,250	6,325	90,575	362
Patuxent Manor	163	282	1.73	70,000	57,222	127,222	509
Riverdale	556	886	1.59	221,000	101,543	322,543	1,290
Sherwood Forest	250	349	1.40	86,750	86,750	173,500	694
Shore Acres	540	508	0.94	126,000	94,352	220,352	881

[1] Note, in Task 1, OSDS nitrogen load and flow and were estimated for each OSDS, based on 9.5 lbs/yr/person/household nitrogen, which equates to per capita flow rates of 78 gpd and 2.6 persons per dwelling unit, or 203 gal/OSDS/day, with OSDS effluent concentration of 40 mg/L, per MDE guidance.

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A second set of flow projections was developed to allow for countywide estimates of OSDS treatment costs. This projection applied the countywide flow factor (250gal/OSDS/day) to each OSDS within the SSA. Tables 2 and 3 summarize the total projected flows by SSA and by planned sewer service type, respectively.

TABLE 2
Inventory of OSDS by Sewer Service Area

Sewer Service Area	Number of OSDS	Percent of OSDS	Number of Developed Accounts	Percent Served by OSDS	OSDS Flow (gpd)	OSDS Flow (mgd)
Annapolis	3,201	7.90%	16,601	19.30%	800,250	0.80
Baltimore City	1,446	3.60%	11,777	12.30%	361,500	0.36
Bodkin Pt-Pinehurst	140	0.30%	160	87.50%	35,000	0.04
Broadneck	9,957	24.50%	30,302	32.90%	2,489,250	2.49
Broadwater	291	0.70%	4,887	6.00%	72,750	0.07
Cox Creek	2,513	6.20%	42,037	6.00%	628,250	0.63
Ft. George Meade	2	0.00%	10	20.00%	500	0.00
Maryland City	160	0.40%	4,336	3.70%	40,000	0.04
Mayo-Glebe Heights	104	0.30%	3,192	3.30%	26,000	0.03
Patuxent	892	2.20%	22,902	3.90%	223,000	0.22
Piney Orchard	17	0.00%	3,629	0.50%	4,250	0.00
Rose Haven	4	0.00%	378	1.10%	1,000	0.00
Rural	21,815	53.60%	22,189	98.30%	5,453,750	5.45
(blank)	142	0.30%	589	24.10%	35,500	0.04
Grand Total	**40,684**	**100.00%**	**162,989**	**25.00%**	**10,171,000**	**10.2**

TABLE 3
Inventory of OSDS by Planned Sewer Service Type

Planned Sewer Service Type	Number of OSDS	Percent of OSDS	Number of Developed Accounts	Percent Served by OSDS	OSDS Flow (gpd)	OSDS Flow (mgd)
Existing Service	1,881	4.60%	118,181	1.6%	470,250	0.47
Future Service	8,322	20.50%	8,674	95.9%	2,080,500	2.08
No Public Service	23,041	56.60%	23,449	98.3%	5,760,250	5.76
Other	18	0.00%	38	47.4%	4,500	0.00
Park	22	0.10%	45	48.9%	5,500	0.01
Planned Service	5,676	14.00%	9,792	58.0%	1,419,000	1.42
Resource Conservation Area	1,584	3.90%	2,165	73.2%	396,000	0.40
(blank)	140	0.30%	587	23.9%	35,000	0.04
Grand Total	**40,684**	**100.00%**	**162,931**	**25.0%**	**10,171,000**	**10.17**

Life-Cycle Costs

A life-cycle cost tool was built and applied to provide estimates of the capital annual costs for each of the treatment alternatives. The life-cycle module was necessary in order to resolve the differing service lives of the various components (tanks, treatment devices, pumps, sewers, etc) within each treatment alternative. Costs were estimated for capital and O&M costs and converted to equivalent uniform annual costs, reflecting expected service life of the infrastructure included in each alternative. Based on user inputs of capital, O&M, energy, and capital replacement costs, the tool outputs the Total Life Cost, Net Present Value (NPV), and Equivalent Uniform Annual Cost (EUAC).

The user can also specify the discount rate and escalation rates for each cost component. For the purpose of this study, and consistent with the U.S. Office of Management and Budget's published nominal interest rates on treasury notes and bonds, a discount rate of 5 percent was used for present-worth cost calculations. Costs were escalated for inflation at a rate of 5 percent for capital costs and 3 percent for O&M costs and energy. A 100-year time period was applied to generate the life-cycle costs and was chosen for efficiency purposes for the computations and also to evaluate the long-term sustainability of the treatment approaches.

This 100-year timeframe was selected to provide an even multiple of the service life of each individual component in each of the treatment systems. This approach saved time in not having to estimate the salvage value for system components that did not reach the end of their service life within the time scale of the cost analysis. For example, sewers were assumed to have a 50-year service life. A 30-year present-worth cost calculation would require that a salvage value be estimated for the remaining 20 years of the sewer life. Similarly, many treatment system components had a service life of 20 years and other components, such as grinder pumps, had only 10 years. The 100-year timeframe allowed full life cycles to be completed for each of these components without the additional expense of the salvage value computation.

This costing approach is well-documented and within standard practice. It has little effect on the outcome of the calculation of the net present worth and equivalent uniform annual cost (Grant, et. al 1990). To respond to comments from the County and MDE on the approach, the sensitivity of the Net Present Value (NPV) and EUAC calculation was examined in relation to the planning period and found to not be a significant factor in the analysis. For example, the NPW of $1.00 discounted at 5 percent over 50 years is $0.09. In terms of EUAC, this translates to $0.0048. Therefore the NPV of the 100-year approach is 9 percent higher than the 50-year present worth cost, and the 100-year EUAC is 0.48 percent higher than the 50-year EUAC.

The methodology for the sewer extension and cluster treatment approaches is discussed in detail in sections to follow.

Preliminary Cost Analysis of Sewer System Extensions

The purpose of this task was to develop planning-level cost estimates for potential sewer extension projects within existing SSAs, as well as for possible extension of sewer service into rural SSAs should that be a cost-effective approach for managing nitrogen loads from OSDS in those areas. For the six SSAs addressed in Task 3 of the CSSP, the output of this task builds on the alternatives evaluation and cost estimates prepared as part of Task 3 of the CSSP. The main focus of this task was to evaluate options and costs to connect each OSDS by extending the County sewer system and to provide a basis of comparison for the other treatment approaches.

Petition Report Summaries

The ten study areas represented areas of the county that were 565 acres on average and ranged from 146 acres to 1,751 acres. With one exception, these areas were all significantly larger than the communities that the County periodically evaluates for sewer extension on a petition basis. In order to extend the data set to examine sewer extension costs for small communities, the project team held a workshop meeting with Anne Arundel County staff to review the output of 14 petition studies that have been conducted for the County by various consultants since January of 1998. The petition areas generally represent areas that are smaller than 200 acres and about 50 acres on average. Pertinent data were extracted and used to populate a petition area database. A summary of key cost data from the 14 petition areas is provided in Tables 4 and 5. The detailed output from the database is provided in Attachment A.

TABLE 4
Summary of Key Data from 14 Selected Petition Reports

	Number of OSDS	Petition Area (acres)	EDUs	Average Dist to Sewer (ft)	Density (# of OSDS per acre)	2007 Adjusted Capital Cost	2007 Capital Cost per OSDS	Annual Cost / OSDS
Mean	47	48	86	917	1.6	$1,597,764	$72,779	$269
Median	23	32	42	842	1.5	$1,525,208	$36,625	$130
Standard Deviation	56	53	104	619	1.2	$1,098,170	$76,455	$391
Minimum	6	3	8	275	0.1	$250,915	$8,782	$33
Maximum	188	193	374	2494	4.1	$4,130,039	$253,490	$1,406

The petition area data was analyzed for relationships between 2007 capital cost per EDU and distance to existing sewers and OSDS density, as shown in Figures 2, and 3. Information found in the literature survey (Lombardo, 2004) indicated that these two variables were related to costs and that they might prove to be useful in extrapolating the study area costs to other areas of the county. The Lombardo study data were updated to 2007 using ENR cost factors and were plotted in Figure 3 for comparison purposes. Strong relationships for these factors were not discernable from the petition report data.

Given that some communities had relatively high costs for extending sewers, despite being close to the County sewer system and having a high density, suggests that other local factors may be driving the cost profile. Other possibilities that were not explored in detail include indirect pathways to existing county sewers, land acquisition costs for sewer alignments outside the public right-of-way, and elevation characteristics that require greater use of pumping to service the community. The petition areas also tend to be small and may not take full advantage of the economies of scale that could be achieved when sewering a larger area. In the Deale Road petition study, it was apparent that the presence of non-residential flows greatly reduced the cost per EDU. The Old Telegraph Road petition area was considered an outlier and was removed from the analysis shown in Figures 3 and 4 and the preceding summary tables.

TABLE 5
Summary of Data Collected from 14 Petition Area Reports with Cost Data Adjusted to Year 2007

Petition Area	Number of OSDS	Petition Area (ac)	EDUs	Current Flows (gpd @ADF)	Ultimate Flows (gpd @ADF)	Ultimate Flows (1,000 gpd @ADF)	AVE Dist to Sewer (ft)	Density (# of OSDS per acre)	Adjusted 2007 Capital Cost	2007 Capital Cost / EDU	2007 Annual Cost per EDU
Deale Road Sewer Extension	36	109	374	76,450	93,600	94	849	0.33	$1,621,590	$ 4,336	$22
Sylvan Shores Sewer Petition	188	46	202	50,500	50,500	51	275	4.09	$1,651,048	$ 8,174	$n/a
Woodhome Circle Sewer Ext.	48	24	54	13,500	13,500	14	335	2.04	$1,353,908	$ 25,072	$30
Wetheridge Ests. Sewer Ext.	11	11	13	3,250	3,250	3	440	0.98	$ 250,915	$ 19,301	n/a
Hanover Road Sewer Petition	19	193	43	4,000	10,750	11	1,756	0.10	$2,562,774	$ 59,599	$113
Edgewater Beach W & S Pet.	149	50	194	27,250	48,500	49	1,068	2.98	$4,130,039	$ 21,289	$56
Locust Grove Sewer Petition	15	95	85	15,750	21,250	21	984	0.16	$2,944,036	$ 34,636	$248
Old Telegraph Rd. WW Petition	7	3	8	2,000	2,000	2	322	2.33	$1,774,428	$221,803	$531
Shady Rest Road Wastewater Pet	15	34	20	5,000	5,000	5	884	0.44	$ 942,411	$ 47,121	$80
Carrs Manor WW Extension	17	7	30	4,000	7,500	8	562	2.62	$2,239,062	$ 74,635	$89
St Bees Drive	26	10	29	7,250	12,000	12	2,494	2.60	$ 653,111	$ 22,521	$138
North Patuxent Rd	37	30	41	9,250	10,250	10	1,391	1.23	$ 513,358	$ 12,521	$73
David Victoria La	6	15	18	1,500	4,500	5	646	0.39	$ 303,192	$ 16,844	$19
Sabrina Park Sanitary Sewer	81	45	87	10,250	21,750	22	834	1.80	$1,428,826	$ 16,423	$56

AR0022121

FIGURE 2
Petition Area Report 2007 Capital Cost / EDU vs. Distance to Sewer with results of Lombardo, 2004 updated to 2007 costs

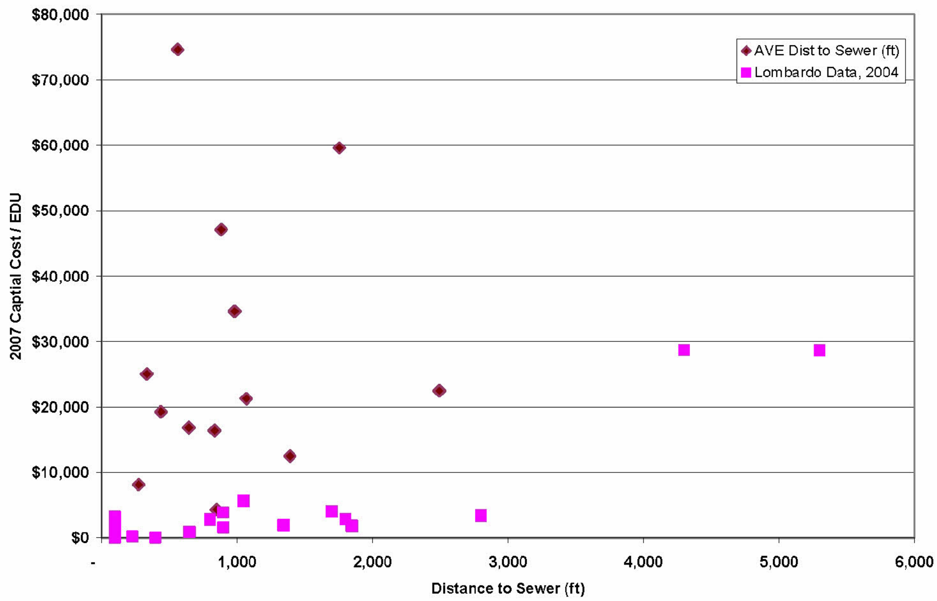
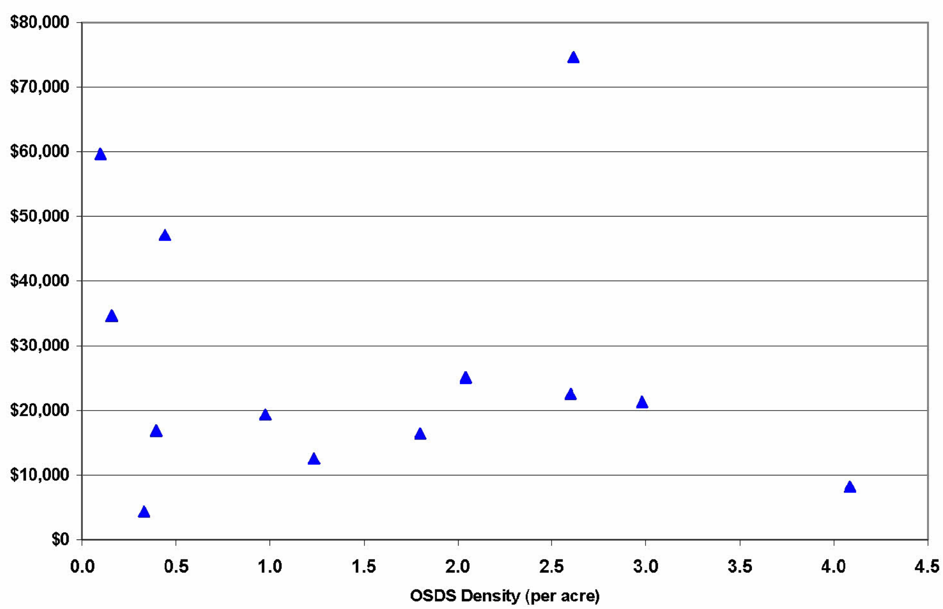


FIGURE 3
Petition Area Report 2007 Capital Cost / EDU vs. OSDS Density



Sewer Extension Approach

For each community, an approach was developed to estimate the cost of installing conventional gravity and/or low-pressure sewer systems to convey raw sewage from each house to a central community pumping station or to the County collection system by gravity. The design of this system, and ultimately the cost of the collection system and pumping station, assumed that all undeveloped parcels within the community boundaries would likely develop and therefore would be allowed to connect to the system in the future. Each community was analyzed to identify the most efficient means of collecting wastewater flows from each existing house for conveyance to the existing County wastewater collection system.

Topographic and tax maps were used to create a base map for the schematic design for a collection system to serve each study area The feasibility of connecting each existing house in the community was carefully considered in the schematic design. The approach assumed that basement service would be provided where possible; however, pumps were not added for the sole purpose of providing basement service when it was possible to service the first floor by gravity. Copies of the schematics are provided in Attachment B, and the CAD files have been archived on the project FTP site.

Analysis of Grinder Pump Influence on Sewer Extension Costs – Terrace Gardens Study Area

Based on County input, efforts were made to minimize the number of grinder pumps and pumping stations to reduce long-term maintenance costs. Multiple connections to the existing wastewater infrastructure were considered and utilized in some study areas to evenly distribute flows and to simplify the overall layout and connection approach. This study area was used to test the life-cycle cost model by analyzing the effect that frequent use of distributed pumping by grinder pumps and low pressure sewer would have on overall costs to serve the study area.

Sewer facilities alignments were completed for the Terrace Gardens study area early in the project using two approaches. The first approach maximized the use of grinder pumps and low-pressure sewers in order to minimize the number of centralized pumping stations. The second sought to centralize pumping and to avoid the use of grinder pumps if possible and at the expense of basement service. Costs were slightly higher for the more capital- intensive option of relying on more gravity sewers and centralized pumping. Table 6 summarizes the costs for the two approaches considered for Terrace Gardens. The approach that minimized the use of grinder pumps was slightly higher. This was likely because of the escalation of capital costs at the rate of 5 percent, which is conservative. The remaining study areas used the latter approach to reflect the County preference for minimizing the use of grinder pumps, which historically have been problematic.

TABLE 6
Cost of Sewer Extension Alternatives for Terrace Gardens

	Total Capital Cost per EDU	Total NPV per EDU	Annual O&M per EDU	EUAC per EDU
Maximize Number of Grinders	$10,100	$15,400	$27	$770
Minimize Number of Grinders	$11,600	$16,500	$29	$830

Analysis of River Crossing vs. Road Distance on Sewer Extension Costs - Arden on the Severn Study Area

The Arden on the Severn study area was situated more than 30,000 feet away from the existing County sewer network by average road distance, but was less than 5,000 feet if the sewer were to be connected to the Broadneck SSA across the Severn River. This alternative examined the cost-benefit of directional drilling approaches versus conventional open cut sewer construction using existing public right-of-ways. The cross-river approach was found to be significantly less expensive, as indicated in Table 7.

TABLE 7
Cost of Sewer Extension Alternatives for Arden on the Severn

Alternative	Total Capital Cost per EDU	Total NPV per EDU	Annual O&M per EDU	EUAC per EDU
Pump Across River	$25,000	$36,000	$47	$1,800
Sewer using public ROW	$33,000	$54,000	$56	$2,700

Component Cost Estimates

The cost-estimating approach employed used a set of typical system components and unit costs that were uniformly applied to each study area. This allowed the costs to extend the sewer system for each area to be calculated consistently. A pricing template was developed by analyzing bid data from recent local projects, supplier/vendor prices, and information from the RS Means Construction Cost database. The results obtained by using the unit prices are meant to represent the total project cost, including accessory items such as mobilization, etc. Each community collection system design uses the component unit costs included in Attachment C - Sewer Extension Cost Estimates.

The sewer system components considered in the analysis were:

- Onsite System Components
- Gravity Sewers
- Force Mains and Low-Pressure Sewers
- Pumping Stations
- Paving
- Accessories
- Cost of Treatment Capacity
- O&M

Onsite System Components

The connection from the existing house to the new collection system will be by gravity sewer house connection (SHC) or by grinder pump. The unit costs presented in this report for these components are intended to cover the complete cost of installation. The 4-inch SHC includes the cleanout and 80 feet of pipe. The grinder pump includes installation and the piping to connect to the collection system.

The cost to abandon existing septic tanks has also been included. In addition, it is assumed that when existing houses are connected to the new collection system, the new SHC will run to just outside the house to assure that any onsite piping problems will be eliminated.

Gravity Sewers

The unit cost of gravity sewers is intended to represent a complete installation, including manholes, excavation, bedding, and refill. A separate cost for trench paving and overlay is included when pipe will be installed in existing roadways.

Force Mains and Low-Pressure Sewers

Similar to gravity sewer costs, the unit costs for force mains and low-pressure sewers represent a complete installation, including valves, connections, excavation, and refill. Pricing for force main installed by horizontal directional drilling (HDD) is separate. A separate unit cost for trench paving is added where pipelines are to be installed in existing roadways and HDD installation is not included.

Pumping Stations

Three pumping station configurations have been used in the schematic designs for the community collection systems. The appropriate pumping station was selected based on flows and the realities of the space limitations in the well-established communities that are to be serviced by the new collection systems. The largest station used for these schematic designs is the standard Anne Arundel County pre-cast wet well/drywell station. This configuration is used for flows between 400 gallons per minute (gpm) and 2,083 gpm. Flows of more than 2,083 gpm require a poured-in-place station; however, the community systems do not have flows of this magnitude.

Two submersible station configurations have been used in the schematic designs. Where an adequate site location appears to be a possibility, the standard County submersible pumping station is used for flows of less than 400 gpm. Where no suitable location for a standard pumping station is apparent, a small submersible station installed in a large manhole has been used. This is not a standard pumping station configuration; however, we understand from discussions with DPW personnel that similar installations have recently been considered and/or approved. Using this pumping station configuration has eliminated numerous grinder pumps. It may be appropriate for the County to consider developing a standard configuration to be used where the site limitations make construction of a standard station impossible, but the benefits of constructing a pumping station are obvious. We understand that previous configurations have used Smith and Loveless equipment.

Paving

Paving costs are based on Anne Arundel County Standard Detail S1, assuming a 6-1/2-inch paving depth and asphalt priced at $110/ton.

Accessories

The cost of accessory items such as mobilization, sediment control, traffic control, and appurtenant items, as well as additional cost for retrofit work and working in close proximity to existing infrastructure, has been calculated by adding pipeline, grinder pumps, paving and septic tank abandonment costs and multiplying by 1.5. Pumping stations, easements, and SHC costs were not included in the computation because these costs for these items were all-inclusive.

The detailed cost analysis spreadsheets for each component are provided in the attachments. To assist in calculating costs for various options, the life-cycle cost module was used to combine the required initial capital investment with the O&M, energy, and capital component replacement intervals. The service life and O&M cost assumptions built into the cost model for the sewer extension components are provided in Table 8.

Cost of Additional Treatment Capacity

The existing County treatment capacities were evaluated. Cost estimates to provide additional treatment capacity for each study area were initially evaluated based on the findings presented in the Anne Arundel County Comprehensive Sewer Strategic Plan, AppendixA_AACo combined Evaluation Expansion Costs - Development of Wastewater Treatment Alternatives and Cost Estimates to Meet Projected 2030 Flows, prepared by Stearns and Wheler, LLC. The estimates for 2030 flows and the recommended capacity for year 2030 were documented for each SSA and were compared to the additional capacity needed to serve the OSDS in each service area listed in Table 8. Based on this comparison, additional capacity was needed in the Annapolis and Baltimore City SSAs. The cost of additional treatment capacity was estimated at $8.0 million for Annapolis and $5.4 million for the Baltimore City SSA, based on the unit treatment costs provided in the CSSP.

Based on further input from the County, the costs of treatment applied to the sewer extension alternative were based on the soon-to-be-updated capital connection fee of $7,050 and the annual sewer charge of $384. The life-cycle cost analysis discussed later computed sewer extension costs with and without this additional treatment cost.

TABLE 8
Projected Future Flows by Sewer Service Area and OSDS Treatment Requirements Beyond Recommended 2030 Capacities

Sewer Service Area (SSA)	Existing Flow (mgd)	Expandable Capacity w/ Current Processes	2030 Flow Estimates (mgd)	Recommended 2030 Capacity (mgd)	OSDS Flow Estimate (mgd)	Addt'l Capacity Needed for OSDS	Addt'l Capacity for OSDS @$10/gal	Addt'l Capacity for OSDS @$15/gal
Annapolis (City and County)	10.05	17.5	12.35	13.0	0.80	0.15	$8,002,500	$ -
Baltimore City [(3)]	3.83	n/a	6.39	6.39	0.36	0.36	$ -	$5,422,500
Broadneck	5.32	12.0	8.84	12.0	2.49	0.00	$ -	$ -
Cox Creek	11.54	15.0	15.01	16.5	0.63	0.00	$ -	$ -
Maryland City	1.13	3.75	1.99	2.50	0.04	0.00	$ -	$ -
Patuxent	5.49	12.0	9.93	12.0	0.22	0.00	$ -	$ -
Total	**37.4**	**60.3**	**54.5**	**62.4**	**4.54**	**0.51**	**$8,002,500**	**$5,422,500**

Operation and Maintenance

O&M costs and service life were estimated for each sewer extension component and are presented in Table 9. O&M costs for pumping stations were itemized separately (see Table 10) along with the associated annual energy costs.

TABLE 9
Component Service Life Assumptions and O&M Costs for Sewer Extension Option

Component	Estimated Service Life (years)	Estimated Replacement Cost (% of original cost)	Annual O&M Cost
Gravity Sewer & Manholes	50	50%	$0.50 / LF
Sewer to House Connection (SHC)	50	50%	
Low-Pressure Sewer & Appurtenances	50	90%	$1 / LF
Grinder Pump	10	17%	$100 / EA
Trench Paving & Overlay	50	5%	
Accessories, Mob, Sed Con, Traffic Con, Etc	50	5%	
Pump Station	20	40%	
Force Main	50	90%	

TABLE 10
O&M Costs for Pumping Station

Pumping Station Size	O&M	Typical Hp	Watt-hr	Watt-hrs/day	kWH/Yr	Total Annual Costs
Small MH Type Stations	$ 3,000	5	3,730	14,920	5,445.8	$3,653
Std. County Submersible Stations	$ 6,000	15	11,190	44,760	16,337.4	$7,960
Std. County WW/DW Stations	$ 9,700	50	37,300	149,200	54,458	$16,235
Poured In Place Stations	$ 9,700	75	55,950	223,800	81,687	$19,502

Note - Pumps assumed to run 4/hrs / day and electrical costs are $0.12 / kwh

Sewer system capacity was evaluated for the point at which the sewer extension connected to the County collection system for each study area. The ultimate flow for each study area, including the OSDS flow projection, was applied in the County SewerCAD models, and the downstream pipe segments were analyzed for the presence of surcharge conditions. Limiting pipe segments and pump stations are presented in Table 11.

TABLE 11
Summary of Downstream Collection System Capacity Deficits for each Study Area

		Existing Flows (gpd)		Projected Flow (gpd)		Projected Flow (gpd)		CSSP Flow Projections for Downstream Sewers								
Study Area	Sewer Connection Location(s)	Existing Flow (gpd)	Existing Excess Full Capacity (gpd)	Existing OSDS Flow (gpd)	Study Area Ultimate Flow (gpd)	Existing OSDS Flow (EDUs)	Study Area Ultimate Flow (EDUs)	2030 Flow (gpd)	2030 Excess Capacity (gpd)	Build-Out Flow (gpd)	Build-Out Excess Capacity (gpd)	D/S Capa. Issues?	D/S Pipe with Capacity Deficit	Scenario with Capa. Issues	D/S PS with Capacity Deficit	Scenario with PS Capa. Issues
Gingerville	19457	300,046	2,167,974	61,016	85,688	244	343	474,057	1,993,963	1,160,220	1,307,801	No				
Terrace Garden	19457	300,046	2,167,974	50,750	129,958	203	520	474,057	1,993,963	1,160,219	1,307,801	Yes	11239A-11238	Build-Out	None	
Arden on the Severn	17387-700189 (U/S pipe of PS # 700189)	54,132	411,081	117,750	163,576	471	654	85,023	380,190	85	380,190	No			None	
Chartwell			**Total**	**369,000**	**720,068**	**1,476**	**2,880**									
	34525	20,075	1,437,192	187,102	365,112	748	1,460	21,824	1,435,444	22,442	1,434,825	Yes	12 segments by 2030 and 22 segments by Buildout	2030 and Buildout	None	
	2465A	2,550,437	10,782,560	115,330	225,055	461	900	3,952,379	9,380,618	5,636,652	7,696,346	Yes	2431-2429	2030	None	
	21327	32,556	1,368,019	29,860	58,268	119	233	49,452	1,351,123	58,178	1,342,398	No			None	
	20228	48,342	1,719,664	36,708	71,633	147	287	108,968	1,659,038	130,423	1,637,583	Yes	18 segments by 2030 and 27 segments by Buildout	2030 and Buildout	None	
Hunters Harbor	31898	3,184	636,761	278,750	452,023	1,115	1,808	3,878	636,067	6,868	633,077	No			None	
Mt Tabor Rd			**Total**	**84,250**	**90,575**	**337**	**362**									
	33608	16,582	779,858	9,247	9,941	37	40	21,888	774,552	21,888	774,552	Yes	2 segments in 2005, 17 by 2030	2005, and 2030	None	
	33951	17,689	525,633	75,003	80,634	300	323	18,848	524,473	18,848	524,473	Yes	10 segments by 2030	2030	None	
Patuxent Manor	28131	235,769	1,982,177	70,000	127,222	280	509	265,519	1,952,427	353,372	1,864,574	Yes	3 segments by 2030, 4 by Buildout		700235	2030
Riverdale	19666	1,904	562,005	221,000	322,543	884	1,290	3,950	559,959	6,367	557,524	No				
Sherwood Forest	27681	248,089	1,571,431	86,750	173,500	347	694	259,747	1,559,773	262,480	1,557,039	Yes	28328-700086	2005	700086	Buildout
Shore Acres			**Total**	**126,000**	**220,352**	**504**	**881**									
	13413	217,197	1,792,635	111,105	194,303	444	777	541,736	1,468,095	1,096,318	913,514	Yes	9 segments (2030)	2030	700026	2030
	5891	4,500	511,707	14,895.35	26,049	60	104	11,676	504,531	24,758	491,449	Yes	3 segments (2030) 8 segments (Buildout)	2030	700024	2030

*Projected capacities are full flow pipe capacity from County Sewer CAD model

Life-Cycle Cost Analysis

The life-cycle cost module was applied using the sewer system component costs to each of the treatment alternatives over a 100-year life cycle. Costs were calculated for capital and O&M costs and converted to EUACs reflecting the expected service life of the infrastructure included in each alternative. Table 12 presents the total initial capital costs, NPV, annual O&M, and EUAC for each study area. Table 13 provides a breakdown of the same cost per EDU using the ultimate flow for each community to allow for uniform comparison with the other alternatives. Table 14 provides the same costs, but reflects the additional cost of treatment to be added at the WRFs.

TABLE 12
Summary of Sewer Extension Cost by Study Area

	Total Capital Cost ($M)	Total NPV ($M)	Annual O&M	EUAC ($M)
Riverdale	$35.8	$53.0	$52,800	$2.7
Arden1 - Pump across creek	$16.2	$23.9	$30,500	$1.2
Arden2 - Pump across country	$21.9	$35.0	$36,500	$1.8
Terrace1 - Max Grinder	$7.2	$11.0	$19,400	$0.6
Terrace2 - Min Grinder	$7.6	$11.9	$21,000	$0.6
Sherwood Forest	$29.3	$62.2	$67,000	$3.1
Gingerville	$9.8	$17.3	$37,500	$0.9
Hunters Harbor/Long Point	$53.7	$83.0	$82,200	$4.2
Chartwell	$75.9	$121.0	$146,000	$6.1
Shore Acres	$23.3	$39.6	$47,600	$2.0
Mt. Tabor Rd - Patuxent	$19.4	$28.8	$43,400	$1.5
Patuxent Manor	$21.9	$37.3	$27,900	$1.9
Total	**$321.9**	**$523.7**	**$611,800**	**$26.4**

TABLE 13
Sewer Extension Costs per EDU, by Study Area

	Number of EDU*	Total Capital Cost per EDU	Total NPV per EDU	Annual O&M per EDU	EUAC per EDU
Riverdale	1290	$28,000	$41,000	$41	$2,100
Arden1 - Pump across creek	654	$25,000	$36,000	$47	$1,800
Arden2 - Pump across country	654	$33,000	$54,000	$56	$2,700
Terrace1 - Max Grinder	718	$10,000	$15,000	$27	$770
Terrace2 - Min Grinder	718	$10,000	$16,000	$29	$820
Sherwood Forest	694	$42,000	$90,000	$97	$4,500
Gingerville	343	$26,000	$47,000	$110	$2,400
Hunters Harbor/Long Point	1808	$30,000	$46,000	$45	$2,300
Chartwell	2880	$26,000	$42,000	$51	$2,100
Shore Acres	881	$26,000	$45,000	$54	$2,300
Mt. Tabor Rd - Patuxent	362	$53,000	$80,000	$120	$4,000
Patuxent Manor	509	$43,000	$73,000	$55	$3,700
Average		**$31,000**	**$52,000**	**$65**	**$2,600**

*Number of EDU is based on ultimate flow projected for each area.

TABLE 14
Unit Sewer Extension Costs Including Additional WRF Treatment Costs, by Study Area

	Number of EDU*	Total Capital Cost per EDU	Total NPV per EDU	Annual O&M per EDU	EUAC per EDU
Riverdale	1290	$35,000	$64,000	$630	$3,200
Arden1 - Pump across creek	654	$32,000	$60,000	$630	$3,000
Arden2 - Pump across country	654	$41,000	$77,000	$640	$3,900
Terrace1 - Max Grinder	718	$17,000	$39,000	$610	$1,900
Terrace2 - Min Grinder	718	$17,000	$39,000	$610	$2,000
Sherwood Forest	694	$49,000	$110,000	$680	$5,700
Gingerville	343	$33,000	$71,000	$690	$3,600
Hunters Harbor/Long Point	1808	$37,000	$69,000	$630	$3,500
Chartwell	2880	$33,000	$65,000	$640	$3,300
Shore Acres	881	$34,000	$68,000	$640	$3,400
Mt. Tabor Rd - Patuxent	362	$61,000	$100,000	$700	$5,200
Patuxent Manor	509	$50,000	$96,000	$640	$4,900
Average		**$38,000**	**$75,000**	**$650**	**$3,800**

*Number of EDU is based on ultimate flow projected for each area.

Enhanced Onsite Sewage Disposal Systems

A literature review was performed to gather relevant data needed to project the cost of upgrading existing OSDS (CH2M HILL, January 22, 2007). The review identified evaluation criteria used in similar programs, applicable technologies for retrofitting existing onsite systems for ENR, and the associated costs. As summarized in Table 15, the survey revealed that most innovative systems will cost between $8,000 and $12,000 per connection, based on 2002 dollars. Cluster systems cost between $8,000 and $15,000 per connection for new construction and between $12,000 and $25,000+ for existing development (2004 dollars). Conventional systems cost between $3,000 and $6,000 based on 2002 dollars. Table 16 summarizes the design and installation costs from the University of Minnesota Extension Service's (Gustafson et al., 2002) innovative onsite sewage treatment webpage.

TABLE 15
Summary of Innovative Onsite Treatment Costs

Treatment Option	Design and Installation (2002)	Appropriateness for Individual Small Lots
Aerobic Tank	$8,000 - $12,000	Yes
Peat Filter	$8,000 - $12,000	Maybe
Single-pass Sand Filter	$8,000 - $12,000	Maybe
Re-circulating Media Filter	$8,000 - $12,000	Yes
Constructed Wetland	$10,000 - $12,000	No
Trench	$3,000 - $6,000	Maybe
Mound	$5,000 - $10,000	Maybe
Drip Dispersal	$8,000 - $12,000	No
Municipal Collection	$5,000 - $10,000+	Yes

Source (Gustafson, et al, 2002)

The costs summarized in Table 15 are similar to those found in other sources from the University of Minnesota as described in the literature survey completed as part of the task 1 characterization work (CH2M HILL, 2006).

Unit cost information from the literature survey was compiled for onsite sewage disposal systems and cluster systems and adjusted to 2007 dollars (see Table 16) using the *Engineering News-Record* (ENR) construction cost index. This table provides an initial snapshot of expected OSDS upgrade and cluster system costs.

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TABLE 16
Summary of OSDS Upgrade and Cluster System Costs Based on Literature Search Results

Treatment System	2007 Cost Low	2007 Cost High
Cluster Systems (New)	$8,860	$16,613
Cluster Systems (Retrofit)	$16,613	$27,688
Innovative Onsite Systems	$8,860	$22,150
Conventional Onsite Systems	$3,323	$6,645

Life-Cycle Cost Analysis – OSDS Upgrades

Discussions with County staff revealed that capital costs to retrofit an individual OSDS were ranging from $17,000 to $21,000 for the treatment system. County staff also reported that drain field replacement costs ranged from $5,000 - $7,000. A life-cycle cost module was developed to combine the required initial capital investment with the O&M, energy and capital component replacement intervals. The initial assumptions built into the cost model are provided in Table 17 and the life-cycles costs in Table 18.

A second set of cost assumptions were developed in a joint workshop meeting with County and MDE staff to refine the cost model based on recent experience with the OSDS upgrades. Based upon MDE input, a drain field replacement interval of 50 years was adopted, with no initial capital cost specified for drain field replacement or renewal. Given the level of known problem areas, it may be unrealistic to assume that all OSDS upgrades would not require some level of initial investment. Health Department personnel indicated that they thought very few drain fields require replacement (less than 5 percent). It is recommended that this issue be looked at in further detail during the implementation planning phase of the project.

MDE indicated that its bid range for upgrade systems ranges from $9,000 to $17,000 for the two projects it has done to date. These figures were used to revise the cost estimates for the OSDS upgrades and served as the basis of comparison with the other treatment approaches. MDE also stated that it believes County costs are higher because of County-imposed monitoring requirements that exceed MDE standards – specifically, the MDE requires seasonal sampling and the County requires monthly sampling. Tables 19 and 20 show the revised input assumptions and resulting life-cycle costs for an OSDS upgrade.

TABLE 17
Preliminary OSDS Upgrade Cost Assumptions

OSDS Upgrade Component	Low	High	Replacement Interval (yrs)
Capital Costs			
Denitrifying Treatment System Upgrade	$17,000	$21,000	20
Drain field Replacement	$5,000	$7,000	25
Annual Costs	**Low**	**High**	
O&M	$160	$350	
Energy *	$500	$800	
Capital Replacement Costs	**Low**	**High**	**Replacement Cost as % of Original Cost**
Treatment System	$8,500	$10,500	50%
Drain field**	$5,000	$7,000	100%

*Energy Usage and duration were computed as an average of 6 selected products from the EPA Technology Verification Program

Table 18 summarizes the unit costs for providing upgrades to the existing OSDS that were used for comparison purposes with the other treatment approaches.

TABLE 18
Preliminary Estimates of Cost per EDU for OSDS Upgrade Option

	Total Capital Cost per EDU*	Annual O&M per EDU	Total NPV per EDU**	EUAC per EDU**
Low	$22,000	$500	$96,000	$4,800
High	$28,000	$800	$140,000	$6,800
Average	**$25,000**	**$650**	**$118,000**	**$5,800**

* includes 5-year O&M agreement as part of the initial capital cost

TABLE 19
Updated OSDS Upgrade Cost Assumptions after MDE input

OSDS Upgrade Component	Low	High	Replacement Interval (yrs)
Capital Costs			
Denitrifying Treatment System Upgrade	$9,000	$17,000	20
Drain field Replacement	$5,000	$7,000	50
Annual Costs	**Low**	**High**	
O&M	$500	$800	
Energy *	$240	$526	
Capital Replacement Costs	**Low**	**High**	**Replacement Cost as % of Original Cost**
Treatment System	$2,700	$5,100	30%
Drain field	$5,000	$7,000	0%

* Energy Usage and duration were computed as an average of 6 selected products from the EPA Technology Verification Program

TABLE 20
Summary of Updated Costs per EDU for OSDS Upgrade Option

	Total Capital Cost per EDU	Annual O&M per EDU	Total NPV per EDU	EUAC per EDU
Low	$9,000	$500	$53,000	$2,700
High	$17,000	$800	$95,000	$4,800
Average	**$13,000**	**$650**	**$74,000**	**$3,750**

Preliminary Cost Analysis of Community Wastewater Systems

The purpose of this task was to develop planning-level unit costs and cost quantity information for estimating the costs of cluster community wastewater systems. For this task, a total of 10 communities were evaluated for the construction of a collection system, community wastewater treatment plant, and treated effluent disposal system. This section describes the selection of treatment and disposal options used in the cost analysis.

Community Wastewater Systems Flow and Load Characterization

Development of Current and Future Flows

The current number of OSDS was determined for each of community study areas. The OSDS were then converted to EDUs to account for any nonresidential OSDS in the study community. An average daily flow of 250 gpd per EDU was applied to calculate the existing flow rates for each community. To estimate the future flows, land use was analyzed to estimate the ultimate number of EDUs and ultimate flow for each community. The flows for the study communities are shown in Table 21. The Gingerville and Hunters Harbor – Long Point communities were not evaluated in this alternative because of the lack of effluent disposal options. However two additional petition areas, Shady Rest Road and Sabrina Park, were added.

The ultimate flows for the study communities cover a broad range, from 5,000 gpd to 721,000 gpd. The smaller flows represent a true community treatment system, while the higher end of the range represents a small municipal treatment plant. The broad range of flows was chosen to evaluate the cost difference between small and large community systems. The treatment plants were sized and costs developed based on ultimate flows from that community.

Development of Loads

Typical constituent loadings were used for sizing the treatment systems. Typical per capita (per person) loadings were obtained from *Wastewater Engineering Treatment and Reuse* (Metcalf and Eddy, 2003). These per capita loadings were then multiplied by 2.6 people per household (EDU) from census data (CH2M HILL, 2007). The mass loadings were then divided by the 250 gpd/EDU flow to obtain constituent concentrations that would be expected at the treatment plants. Table 22 shows the typical per capita loading used and resulting average concentration at the treatment plants.

TABLE 21
Flow Summary for Study Communities

Study Area	Current Estimated EDU's	Current Project Flows (gpd)	Ultimate Projected EDU's	Ultimate Projected Flows (gpd)
Terrace Gardens	203	50,750	520	129,958
Arden on the Severn	471	117,750	654	163,576
Chartwell	1,476	369,000	2,880	720,068
Mt. Tabor Rd	337	84,250	362	90,575

TABLE 21
Flow Summary for Study Communities

Study Area	Current Estimated EDU's	Current Project Flows (gpd)	Ultimate Projected EDU's	Ultimate Projected Flows (gpd)
Patuxent Manor	280	70,000	509	127,222
Riverdale	884	221,000	1,290	322,543
Sherwood Forest	347	86,750	694	173,500
Shore Acres	504	126,000	881	220,352
Shady Rest Road	20	5,000	20	5,000
Sabrina Park	41	10,250	87	21,750

TABLE 22
Summary of Constituent Concentrations for Wastewater

Parameter	Load (g/capita-day)	Concentration (mg/L)
Biochemical Oxygen Demand (BOD)	85	234
Total Suspended Solids (TSS)	95	261
Ammonia Nitrogen (NH_3-N)	7.8	21
Organic Nitrogen	5.5	15
Total Kjeldahl Nitrogen(TKN)	13.3	37
Organic Phosphorus (P)	1.23	3
Inorganic P	2.05	6
Total P	3.28	9

Screening and Selection of Treatment Alternatives

Basis of Selection

The screening and selection of treatment alternatives were guided by the following factors:

- **Discharge Requirements:** Individual septic systems are not required to have a permit to discharge wastewater and are considered a nonpoint source of pollution. Connecting these individual systems makes them into a point source of pollution and a discharge permit is then required. The level of treatment required of the community systems is chiefly governed by the requirements needed to obtain a discharge permit for the treated wastewater.
- **Level of nutrient removal:** The ability of a treatment technology to remove nutrients from the wastewater, specifically nitrogen. A higher level of nitrogen removal is achievable through small community systems than is possible with individual onsite systems. This higher the level of treatment gained from the community treatment plants

may offer the best solution for nutrient reduction from some areas currently served from individual systems.

- **Operational considerations:** It is anticipated that the community treatment systems would be operated by Ann Arundel County staff. An easy–to-operate plant is advantageous because there could be many community plants spread out over the county that would have to be operated by personnel who would be required to split their time between several plants.
- **Treatment System Size:** The size of the community to be served has a bearing on the type of treatment technology to be used. A treatment system that works well with a plant flow of 10,000 gpd may not be practical for a plant with a flow of 500,000 gpd, and vice versa.

Selected Treatment Options

Three general treatment technologies were chosen as the basis for the community system cost analysis. The technologies chosen fit, to varying degrees, the selection criteria mentioned above. The technology options used were:

Option 1
Trickling filter
Effluent TN < 20 mg/L
Applicable for flows < 5,000 gpd

Option 2
Sequencing Batch Reactor
Effluent TN < 8 mg/L
Applicable for flows > 5,000 gpd

Option 3
Membrane Bioreactor
Effluent TN < 3 mg/L
Applicable for flows > 20,000 gpd

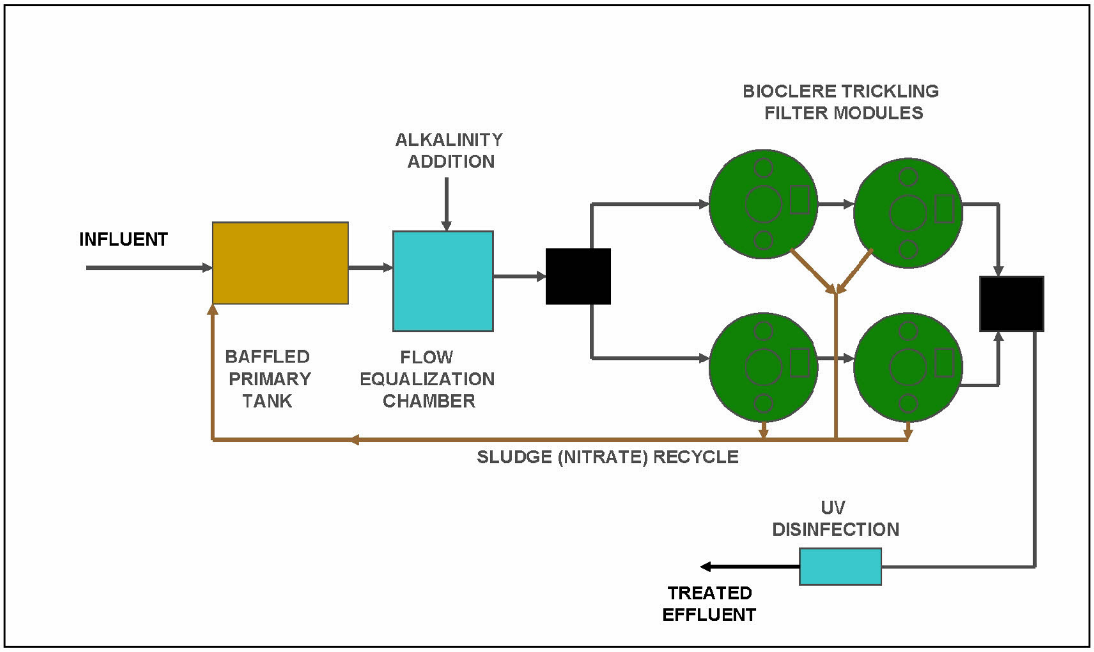
Each of these treatment options is designed treat the influent wastewater to meet the required discharge limits for each community. Sludge generated at each site would be stored and liquid-hauled to one of the County's existing treatment plants for processing.

Option 1 - Trickling Filter

In a trickling filter, biological treatment is accomplished by microorganisms that grow on plastic media. The advantage of a fixed film process such as a trickling filter is that they are easy to maintain and require very little operation adjustment. The disadvantage is that trickling filters cannot produce the high of level of treatment of an activated sludge process.

The trickling filter used for the cost analysis was the Bioclere, which is manufactured by Aquapoint. Similar systems are manufactured by Waterloo Biofilter and SepiTech. A typical flow schematic for the treatment system based on the Bioclere system is shown in Figure 4.

FIGURE 4
Bioclere Trickling Filter Flow Schematic



Raw wastewater enters into a primary settling tank, where solids drop out. The overflow moves into the Bioclere unit where a pump recirculates the wastewater over the plastic filter media. Solids settle in the cone-shaped bottom of this unit and are pumped back to the primary settling tank. The unit provides BOD removal and nitrification. Nitrogen removal is accomplished by the recycling of flow from the Bioclere unit back to the primary settling tank. The nitrate in the recycle flow is denitrified (converted to nitrogen gas) in the anoxic conditions that exist in the primary settling tank.

Figure 5 shows a typical Bioclere filter unit.

FIGURE 5
Typical Boiclere Filter Unit

Source: Aquapoint

The Bioclere system is applicable for very low influent flows, ranging from hundreds of gallons per day up to 40,000 gpd. The treatment units can be arranged in parallel to increase the capacity of the system. When flows are above 40,000 gpd, other treatment technologies are more cost-effective than the increasing number of Bioclere trains. The Bioclere can produce effluent quality of 20 mg/L TN when operated in this configuration.

One of the main advantages of the Bioclere system is that is its maintenance requirements are very low, therefore reducing operational costs. On the other hand, its lower quality effluent and smaller flow range applicability eliminates the opportunity to use it in larger applications.

Option 2 – Sequencing Batch Reactor

A sequencing batch reactor (SBR) is an activated sludge process that performs BOD removal, biological nutrient removal, and clarification in a single tank. The biological step of the treatment process consists of four main stages: fill, react, settle, and decant. During the react stage, the process is alternated between aerobic and anoxic zones to allow nitrification and denitrification. During the settle stage, the process acts as a secondary clarifier. In this study, the SBR system considered is manufactured by Aqua-Aerobic Systems, Inc.

The typical flow schematic for an SBR plant is shown in Figure 6. The headworks would consist of screening and grit removal for the raw wastewater. A minimum of two SBR tanks is recommended such that the one tank can always be filling while the other tank is settling and decanting. An equalization tank is often added after the SBR to equalize the intermittent decant flows prior to disinfection.

FIGURE 6
Sequencing Batch Reactor Flow Schematic

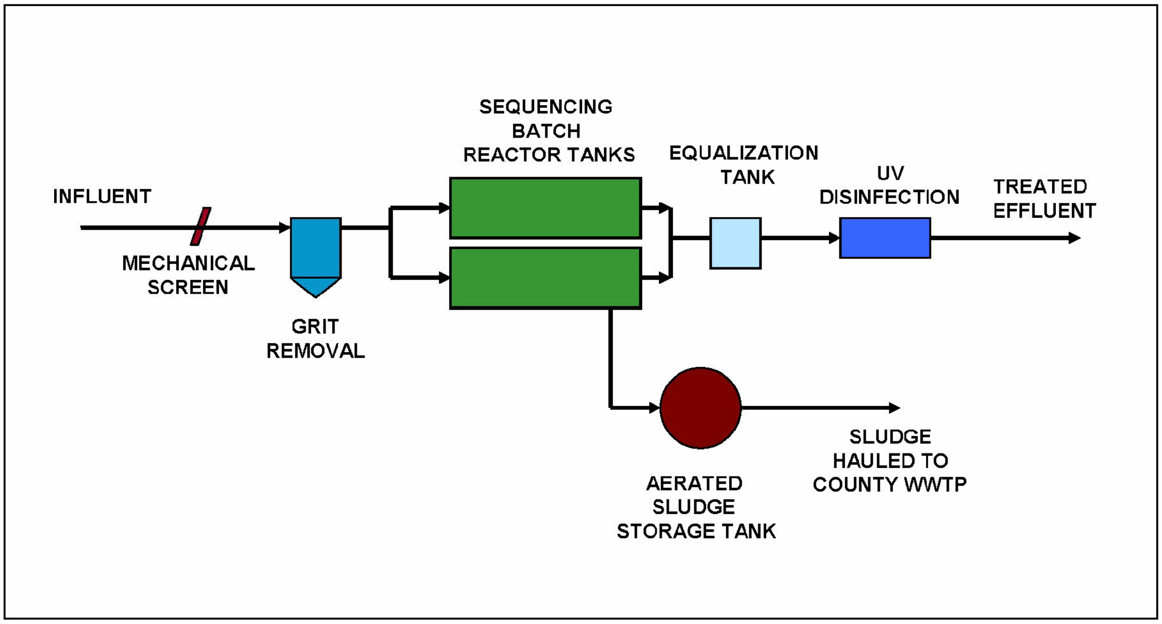
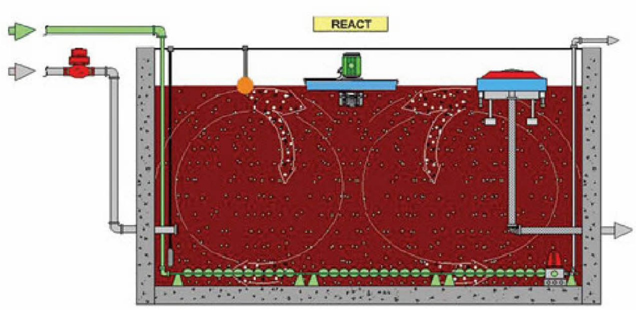


Figure 7 shows a section view of a typical SBR basin with a floating decanter.

FIGURE 7
SBR Basin with Floating Decanter



© 2006 Aqua-Aerobic Systems, Inc.
Source: Aqua-Aerobics Systems

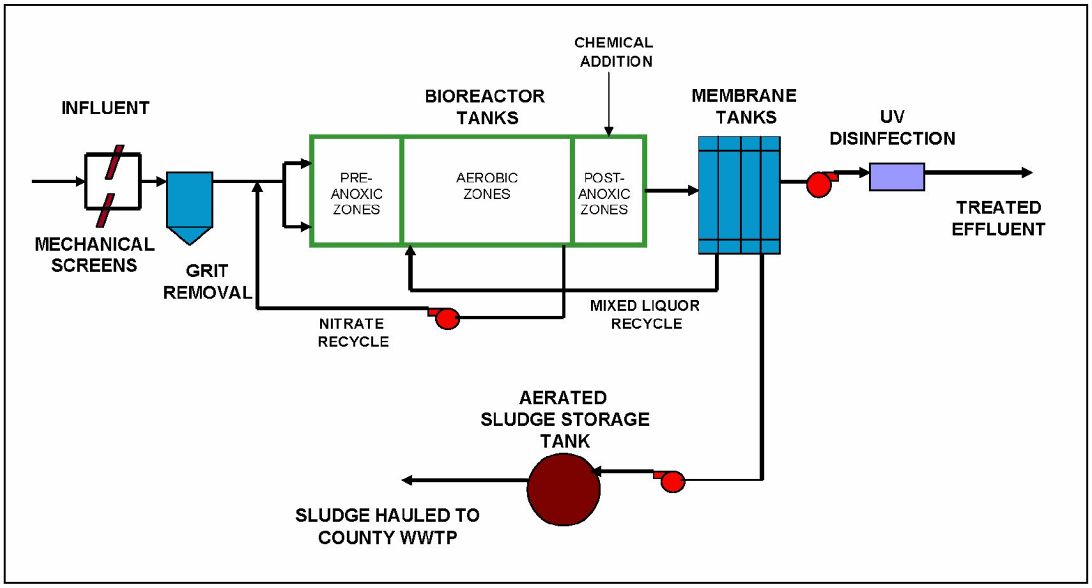
SBRs are applicable for a very wide range of flow rates, including small packaged systems for flows lower than 75,000 gpd. SBRs can reach very low nitrogen effluent levels, and an effluent TN of < 8 mg/L was used for this match discharge limits.

The advantages of an SBR are its ability to meet stricter discharge limits and perform the treatment within a single tank. Some of the disadvantages are that more process control is needed to maintain the activated sludge process, along with the added controls needed to run the treatment sequence.

Option 3 – Membrane Bioreactor

A membrane bioreactor (MBR) is an activated sludge process in which the clarification and effluent filtering steps are replaced by a membrane filter. Figure 8 shows a typical flow schematic for an MBR plant setup for nutrient removal. Biological treatment is set up in a modified 4-stage Bardenpho process with an aerobic zone for BOD removal and nitrification and pre- and post-anoxic tanks for denitrification.

FIGURE 8
Membrane Bioreactor Flow Schematic



MBRs typically operate with mixed liquor suspended solids (MLSS) values ranging from 10,000 mg/L to 15,000 mg/L. One of the main advantages of MBRs is their smaller footprint (because of higher operating MLSS concentrations) and high effluent quality compared to other treatment processes. In this study, the MBR system was based a system manufactured by Zenon Environmental Corporation. Figure 9 shows a pre-packaged Z-MOD MBR System.

FIGURE 9
Z-MOD MBR System

Source: Zenon Environmental Corporation

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MBRs are available in pre-packaged, more cost-effective alternatives, applicable to a wide range of flow rates. In the lower end they can treat flow rates as low as 20,000 gpd and up to 2 mgd.

When used in conjunction with chemical addition, MBRs can reach very low nitrogen and phosphorous effluent levels. Metal salts such as alum or ferric chloride are added to precipitate and remove phosphorus. Methanol is added in the post-anoxic zone as a supplemental carbon source to allow complete denitrification. In this study, the total nitrogen (TN) limit was established at 3 mg/L and the phosphorus effluent limit to 0.3 mg/L.

The advantages of the MBR are the small footprint needed and excellent quality effluent that is suitable for reuse application or direct discharge. The main disadvantages of MBR systems are their high energy consumption and general complexity of equipment.

Evaluation of Disposal Options

Effluent disposal options were evaluated for each of the study communities at a broad conceptual level. This initial evaluation found that two of the areas, Gingerville and Hunters Harbor – Long Point, did not appear to have any viable disposal options.

Finding workable disposal options was a difficult task even at the conceptual level. The current regulatory framework makes it very difficult to permit a new point source as would be required for the community treatment systems. The construction of a community treatment system to replace substandard septic systems would be a great benefit to the Chesapeake Bay; however, no framework currently exists to aid or encourage this process.

A cost estimate for the construction of an effluent disposal system was prepared for each of the 10 communities. Table 23 lists the options used for each of the communities. Where a disposal option was not available, it was listed as "none."

TABLE 23
Effluent Disposal Options

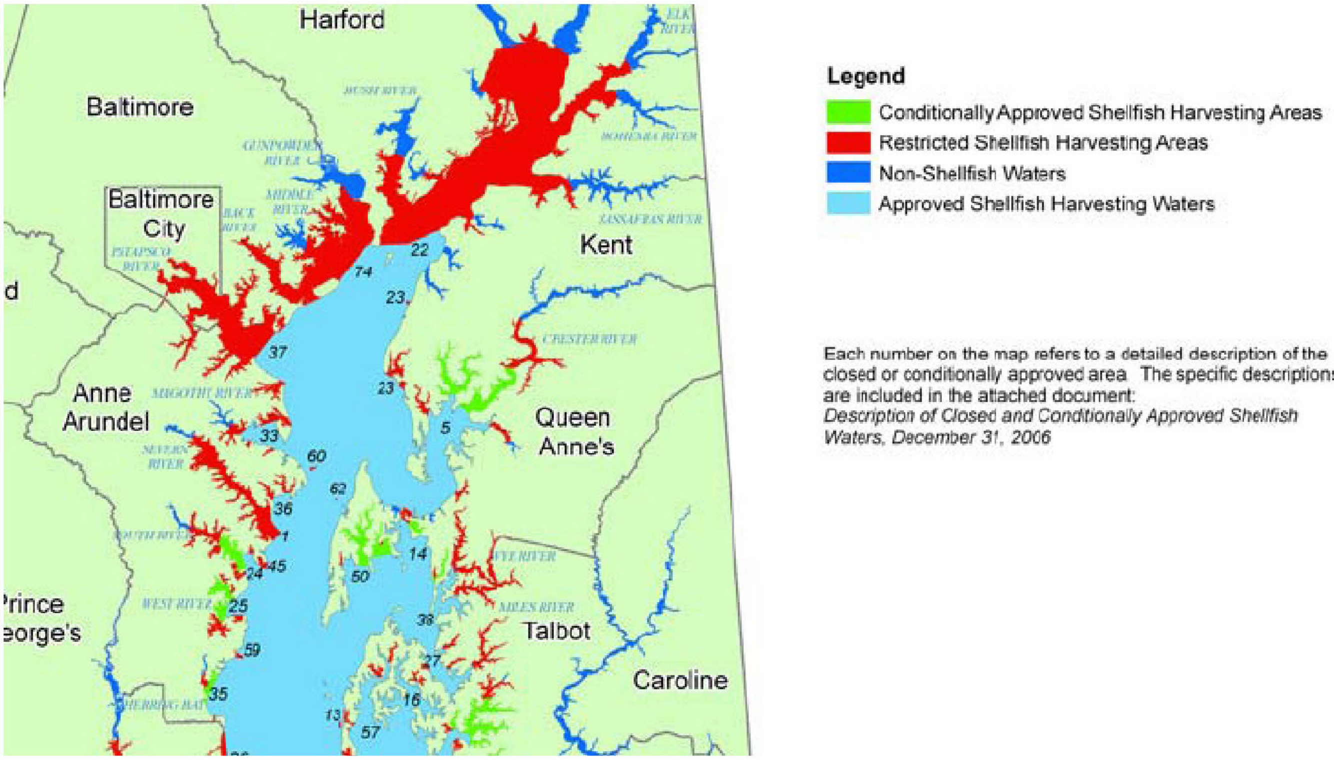
Community	Direct Discharge	Land Application
Terrace Gardens	None	Deep trenches, effluent could be reused in summer months for irrigation of golf course or community college
Arden on the Severn	Severn River	Deep trenches, effluent could be reused in summer months at ball fields.
Chartwell	Severn River	Deep trenches, effluent could be reused in summer months the County's Kinder Farm Park.
Mt. Tabor Rd	South River	Spray irrigation on crop land.
Patuxent Manor	Patuxent River	Rapid infiltration basins.
Riverdale	Magothy River	None
Sherwood Forest	None	Deep trenches, effluent could be reused in summer months for irrigation of golf course.
Shore Acres	None	Deep trenches, effluent could be reused in summer months for irrigation of golf course.
Shady Rest Road	None	none
Sabrina Park	Severn River	none

Direct Discharge

A direct discharge to surface waters would require a new National Pollution Discharge Elimination System (NPDES) discharge permit, which is unlikely to be obtained without some regulatory flexibility based on removing nonpoint source pollution and replacing it with lesser amount of point source pollution. The two main difficulties with a direct discharge are limits on TN and phosphorus discharges and impacts to shellfish harvesting waters:

- **Nutrient limits:** Ann Arundel County is in the process of negotiating two watershed-based nutrient discharge permits for the discharge of nitrogen and phosphorus from the County's seven existing wastewater treatment plants with NPDES permits. The construction of a new community treatment system with a direct discharge would require using a portion of this nutrient discharge allotment from the appropriate watershed-based nutrient discharge permit for the new source. The draft watershed-based nutrient discharge permit proposed by MDE contains a provision that would allow the County's watershed nitrogen and phosphorus limits to be increased if septic tanks are taken offline and connected to a public sewer, although the permit states that statewide policy will be needed to calculate the amount of additional waste load allocation received for each septic system taken offline. The draft watershed-based nutrient discharge permit also contains a provision that would allow new County-owned facilities to fall under the same permit with MDE's approval. Should the County be able to use its watershed-based nutrient discharge permit for new community treatment systems with direct discharges, the systems would need to operate within MDE's current ENR guidelines, which are:
  - TN < 8 mg/L and TP < 2mg/L for minor facilities (design flow less than 0.5 mgd)
  - TN < 4 mg/L and TP < 0.3 mg/L for major facilities (design flows of 0.5 mgd or greater).
- **Shellfish harvesting waters:** A shellfish closure area is required around each direct discharge point from a wastewater treatment plant. Maryland has a policy that forbids creating new shellfish closure areas. Therefore, no new direct discharges are allowed into designated shellfish harvesting waters. A map of these areas is shown in Figure 10. Six of the study communities lie near rivers that are not designated as shellfish harvesting waters and may be allowed to direct discharge. In these rivers, there may be other water quality concerns that would affect permittability for a new direct discharge; however, the scope of this study did not include further investigation and was more focused on developing potential costs.

FIGURE 10
Maryland Oyster and Clam Harvesting Areas (Source MDE, 12/2006)



The cost analysis for community treatments that have a direct discharge was based on the construction of an MBR that would meet the effluent nutrient levels of TN < 3.0 mg/L and TP < 0.3 mg/L.

Land Application

Land application of treated effluent encompasses the reuse of treated wastewater for irrigation, subsurface disposal to groundwater, or a combination of both. The regulatory requirements for land application are defined by MDE's *Guidelines for Land Treatment of Municipal Wastewaters (2005)*. These guidelines include requirements for spray irrigation, drip irrigation, overland flow, and rapid infiltration beds. Included in these guidelines are requirements for setbacks, treatment levels, necessary hydrogeologic conditions, maximum application rates, etc.

In addition to MDE's published guidelines for land application, other methods for effluent disposal were also considered, including subsurface disposal in deep trenches and discharge to wetlands.

A separate cost analysis was performed for each of the communities to select the potential land application method and conceptual locations. Various types of information were reviewed for the sites, including the following:

- Available mapping of topography and land use and aerial photography

- Information provided by the Anne Arundel County Department of Health on soil percolation rates, type soils in each area, and depth to groundwater

The cost analyses for the land application alternatives were based on the construction of an SBR at the community treatment plant, followed by the most applicable type of land application for that particular area. MDE has a policy that all new onsite wastewater disposal systems must be preceded by a treatment process capable of achieving an effluent TN of < 8.0 mg/L. This level of treatment is attainable with an SBR or MBR but is not practical with a trickling filter system without the addition of more downstream processes.

Spray Irrigation

Spray irrigation was used for the effluent disposal cost analysis for the Mt. Tabor Road study area because of cropland near the community. Most of the study communities were not well-suited for spray irrigation because of the lack of available land or poor, clayey surface soils. The large size of the community study areas make slow-rate application processes such as spray and drip irrigation infeasible because the large land requirements.

Spray irrigation can be a good reuse of treated wastewater and can have a positive environmental benefit by reducing the amount of groundwater used for irrigation. Spray irrigation can be used on cropland, golf courses, or planted forest areas. Spray irrigation works best during the growing season when plants can uptake the remaining nitrogen in the treated wastewater. During the winter months or during wet periods, the effluent must be stored until conditions are favorable.

The requirements for spray irrigation system are detailed in MDE's *Guidelines for Land Treatment of Municipal Wastewaters*. Some of the requirements are mandatory: setbacks for application, maximum application rates based on soil properties, minimum 90-day storage, and monitoring.

Drip irrigation

Drip irrigation was used for the effluent disposal cost basis for the Shady Rest Road and Sabrina Park petition areas. Typical drip irrigation systems being used consist of a series of buried laterals containing dosing emitters. The laterals are pressurized and emitters are design to give an even distribution of flow. The treated effluent is typically put through a filtering system to prevent clogging of the emitters.

A drip irrigation system can be operated all year. When plant uptake of water and nutrients is not occurring, the treated effluent percolates to groundwater. The requirements for this type of system are also included in MDE's *Guidelines for Land Treatment of Municipal Wastewaters*. These guidelines include a required 30 days of storage.

Rapid Infiltration Beds

Many of the selected study communities have deep sands with sufficient depth to groundwater (> 10-ft), which are conducive to the use of rapid infiltration beds. The surface soils are poor and would have to be removed to construct the beds. The removal of the surface soils should be discussed with MDE, as this may be in conflict with its current policy.

Rapid infiltration beds were chosen as an alternative for the Patuxent Manor community because of its rural location and availability of vacant land nearby for the construction of the system. Other communities were more suited for a deep trench type of system that does not require open adsorption beds.

Again, the requirements for rapid infiltration beds can be found in MDE's *Guidelines for Land Treatment of Municipal Wastewaters*. Rapid infiltration beds need much less land area and are not required to have provisions for effluent storage.

Deep Trenches

Deep trench disposal systems are used frequently for individual systems in the study communities. Construction of a deep trench disposal field consists of excavating a deep trench through the surface clay soil layer down into deep sands. The trench is then filled with gravel, and a 4-inch perforated lateral pipe within 4 feet of the surface is used to distribute wastewater. The deep trench system provides the same type of infiltration of treated effluent to groundwater as a rapid infiltration bed, except less soil has to be removed and the area above the trench can be used for turf, landscaping, parking, or other uses.

The requirements for a deep trench system can be found in Anne Arundel County Health Department's *Private Sewage Disposal Code* (2003). MDE does not officially recognize deep trench systems for community disposal systems.

Wetlands

The use of wetlands for effluent disposal was evaluated as a part of this study for the Hunters Harbor study area, and a separate technical memorandum documents the analysis in Attachment F. The Hunters Harbor study area was particularly challenging in terms of identifying suitable land areas to site a cluster treatment facility and associated land application site. The area has high ground levels, poorly drained soils, and a portion of it is designated as a septic tank problem area by the County Health Department, thus making the area poorly suited for land application of cluster treatment effluent and the continued use of OSDS. This section of the Chesapeake Bay is classified as shellfish harvesting waters, which would preclude the construction of a new direct discharge. Disposal options were also limited by the prevalence of Resource Conservation Areas, and the area is not designated for sewer service in the future. Screening analysis of vacant land areas revealed that wetlands were located adjacent to the site, and in the absence of any other alternative beyond upgrading the existing OSDS, a wetland treatment option was evaluated for the Hunters Harbor and was found to have several benefits. Discharging treated effluent to natural wetlands would provide additional polishing of the effluent before it enters surface waters. The wetlands would also act as a buffer between the shellfish harvesting waters and the treatment plant if there was a failure of the plant's disinfection system and reserve storage capacity.

The preliminary investigation into using natural wetlands at the Hunters Harbor study area revealed that more than 100 acres of wetlands would be required, while only about 24 acres of suitable wetlands were present in the area. The use of wetlands would be more suitable for smaller communities. The typical hydraulic loading to the wetlands can range from 0.16 inch/day to 0.83 inch/day, depending on the level of treatment provided ahead of the wetlands. One of the limiting factors is that hydraulic loading must be properly defined in order to preserve the existing wetland vegetation.

Other Study Tasks

Septic Tank Effluent Pumping Systems

One of the subtasks of this study was to evaluate the use of septic tank effluent pumping (STEP) systems in conjunction with the construction of community treatment systems. This type of system would consist of leaving the existing septic tanks at each residence and installing a low-pressure grinder pump to pump the septic tank effluent to a community treatment system.

This type of STEP system would produce higher operating and maintenance costs for the collection system and could also be detrimental to the community treatment system. The addition of a grinder pumps at each residence would require significant maintenance for pump repair and replacement and periodic pumping of septic tanks.

The STEP system could also pose additional problems for a community treatment plant. With connection to the effluent of the septic tanks, there is likely to be inflow and infiltration (I/I) in the existing old septic tanks and piping to the houses. Piping should really be replaced all of the way to the house foundations to eliminate this source of I/I. The second problem is that the septic tanks will remove a significant portion of the BOD in the wastewater but will pass the nitrogen on to the treatment plant, which will likely inhibit biological nutrient removal (BNR) at the treatment plant. In order to have sufficient amount of carbon source for BNR, the BOD:TKN ratio should be greater than 3:1, which may not be the case when the BOD is being removed in the septic tanks.

Bodkin Point

Another subtask in this study was to evaluate upgrading the Bodkin Point community treatment system for nitrogen removal. The Bodkin Point – Pinehurst subdivision has 28 total lots, of which 19 lots are connected to a community septic system and 9 have individual onsite treatment systems. The existing treatment system is a STEP system connected into a communal raised bed drain field.

A conceptual cost was prepared to construct a trickling filter treatment system to remove TN down to < 20 mg/L. This type of system should be acceptable to the MDE because the average flow for the existing 19 lots would be 4,750 gpd (19 EDUs x 250 gpd/EDU). Note that new systems' > 5,000 gpd are suppose to meet an effluent TN of < 8 mg/L. The estimate is based on reusing the existing STEP system and drain fields. The estimated construction cost is approximately $620,000. This is a high price for a limited amount of nitrogen reduction from these 19 OSDS.

Life-Cycle Cost Analysis

Methodology

Preliminary cost estimates were developed for each of the community treatment and disposal systems and included capital cost, O&M costs, and equivalent uniform annual costs (life-cycle costs). These costs were then added to the costs associated with the construction and operation of a collection system to form the complete costs of the community treatment system alternative.

Capital Costs

Capital costs were developed by calculating individual costs for each of the main unit processes in the treatment plant (i.e., headworks, process, disinfection, effluent disposal, and sludge storage). Costs for the main mechanical and process equipment were obtained from manufacturers. Costs of concrete work and buildings were calculated based on sizes and current market conditions. Once costs were obtained for each treatment process, percentages were added to the subtotal for civil and site work, process and yard piping, electrical, instrumentation, and general conditions. Cost analysis summary sheets for each cluster treatment system can be found in Attachment E. Tables 24 and 25 summarize the items included for each unit process of the treatment plant.

TABLE 24
Items Included in Headworks for Each Alternative

Item	MBR	SBR	Trickling Filter
Buildings			
	Enclosed influent building to house the screening and grit removal equipment	Enclosed influent building to house the screening and grit removal equipment	None
Equipment			
Screening	Two* fine screens (Raptor rotating drum screen by Lakeside Equipment)	One fine screen (Raptor rotating drum screen by Lakeside Equipment)	None
Grit Removal	One grit removal system (Pista Grit by Smith and Loveless)		Primary settling tank used

* Pre-Treatment requires redundancy because of the system's reliance on effective screening.

TABLE 25
Biological Treatment Process Components Included in Each Alternative

	MBR	SBR	BIOCLERE
Buildings			
	Storage Room	Storage Room	Storage Room
	Electrical Room	Electrical Room	Electrical Room
	Operations Building	Operations Building	Operations Building
	MBR Pump Gallery	Chemical Storage Room	
	Chemical Storage Room		
Concrete			
	Equalization Tank	SBR Tanks	Primary Tank
	Bioreactor (Anoxic)	Equalization Tank	Equalization Tank
	Bioreactor (Aerobic)		Distribution Box
	Membrane Tanks		Mounting Pads
Equipment			
	MBR Units (1)	SBR Units (2)	Bioclere Units (3)
	Miscellaneous Valves	Miscellaneous Valves	Miscellaneous Valves
	Miscellaneous Sampling Equipment	Miscellaneous Sampling Equipment	Miscellaneous Sampling Equipment
	Chemical Addition Tank (Alkalinity)	Miscellaneous Stairs and Railings	
	Chemical Feed Pumps	Effluent Water System	
	Nitrate Recycle Pumps (400%Q)		
	Methanol Tank		
	Methanol Pumps		
	Methanol Piping		
	Effluent Water System		

1) Scope of Services of Zenon includes aeration equipment for membranes and aerated tank, membrane equipment, recirculation equipment (piping), permeate pumps, piping and valves, backpulse equipment (backpulse tank, level control piping and valves), PLC, HMI, motor starters, startup and training, anoxic mixer, transfer pump and first year 24/7 autodialer service.

2) Scope of Services of Aqua-Aerobics includes SBR equipment, mixers, decanters, transfer pumps, fine bubble diffusers for SBR, PD blowers, level sensors for SBR tanks, instrumentation for SBR system, equalization tank coarse bubble diffusers, PD blowers, levels sensors and controls.

3) Scope of Services of Aquapoint includes equalization pump package, alkalinity feed system, Bioclere units, feed pump package, anoxic tank internals, post aeration tank internals and onsite training.

Disinfection

The UV system (based on a system manufactured by Trojan UV) sizes considered in this study depended on the disinfection limit desired in the effluent water. For direct discharge locations, the fecal coliform limit was established as 14 colonies /100 mL, which would be the most restrictive requirement if discharging into shellfish harvesting waters. For land application purposes, the disinfection limit established was 3 FC/100 mL, which is the most restrictive level used for spray application on golf courses.

Sludge Storage

Costs for sludge storage were calculated based on estimated sludge production for the various systems. Sludge holding tank and blower sizes were adjusted to provide roughly 7 days of sludge storage onsite, to allow sludge to be periodically hauled to an existing County plant for processing.

Effluent Storage for Land Application

A total of 30 days of effluent storage is required for drip irrigation systems and 90 days for spray irrigation systems. This length of storage, combined with the size of the study communities, requires the storage of a very large volume of treated effluent. Storage costs were based on the construction of a lined earthen lagoon. In areas of high groundwater, the lagoons would have to be bermed above grade.

Other Costs

Other cost to construct the community treatment plants and effluent systems include providing power to the site, providing instrumentation and control, site work, pumping wastewater to the plant, and conveying treated wastewater to the land application or outfall location. Land acquisition costs for the community treatment plants and land application systems were based on $30,000/acre unless it was intended that community- owned areas were going to be used.

O&M Costs

O&M cost for treatment and disposal were calculated to include labor costs, equipment maintenance, chemical costs, and power requirements. Labor costs included a half-time employee for plants with flows below 100,000 gpd, and a full-time employee for plants with flows above 100,000 gpd. Maintenance costs were calculated as 2 percent of the total equipment cost, and membrane replacement cost were obtained from the manufacturer. Chemical usage was estimated for phosphorus precipitation, carbon addition, and membrane cleaning where applicable. Power requirements were based on main equipment power usage, along with an allotment for overall usage at the plants.

The estimated service life of components is indicated in Table 26.

TABLE 26
Component Service Life

Component	Estimated Service Life (years)	Estimated Replacement Cost (percentage of original cost)
Buildings and Tanks	100	N/A
Process Equipment	20	100%
Piping	50	50%
Electrical Equipment	50	50%
Instrumentation	10	50%
Effluent Disposal Components	50	50%

Life-Cycle Costs - Community Cluster Treatment Systems

Life-cycle costs were generated for each of the community treatment and disposal systems. The life-cycle costs encompass the initial capital construction costs, periodic replacement of components, and annual O&M costs. The total cost of cluster treatment was calculated in terms of initial capital cost, NPV, annual O&M, and EUAC for each study area. Table 27 summarizes total cost by study area and Table 28 provides a breakdown of costs per EDU using land application for ultimate disposal.

TABLE 27
Total Costs for Cluster Treatment with Land Application

Study Area	Total Capital Cost ($M)	Total NPV ($M)	Annual O&M NPV ($M)	EUAC ($M)
Riverdale	N/A	N/A	N/A	N/A
Arden on the Severn	$22.3	$41.3	$0.2	$2.1
Terrace Gardens	$12.8	$27.4	$0.2	$1.4
Sherwood Forest	$30.4	$71.3	$0.2	$3.6
Hunters Harbor/Long Point	N/A	N/A	N/A	N/A
Chartwell	$90.6	$168.0	$0.6	$8.5
Shore Acres	$29.9	$55.1	$0.2	$2.8
Mt. Tabor Rd - Patuxent	$27.1	$50.1	$0.2	$2.5
Patuxent Manor	$18.8	$44.9	$0.2	$2.0

TABLE 28
Cost per EDU of Cluster Treatment with Land Application

Study Area	Number of EDUs	Total Capital Cost per EDU	Total NPV per EDU	Annual O&M per EDU	EUAC per EDU
Riverdale	1290	N/A	N/A	N/A	N/A
Arden on the Severn	654	$34,100	$63,100	$309	$3,180
Terrace Gardens	718	$17,800	$38,200	$241	$1,930
Sherwood Forest	694	$43,800	$103,000	$299	$5,170
Hunters Harbor/Long Point	1808	N/A	N/A	N/A	N/A
Chartwell	2880	$31,500	$58,400	$204	$2,940
Shore Acres	881	$34,000	$62,600	$238	$3,150
Mt. Tabor Rd - Patuxent	362	$75,000	$138,000	$591	$6,970
Patuxent Manor	509	$37,000	$88,200	$399	$3,980

Table 29 summarizes total cost by study area and Table 30 provides a breakdown of costs per EDU using direct discharge for ultimate disposal.

TABLE 29
Total Cost of Cluster Treatment with Direct Discharge

Study Area	Total Capital Cost ($M)	Total NPV ($M)	Annual O&M	EUAC ($M)
Riverdale	N/A	N/A	N/A	N/A
Arden on the Severn	$24.1	$45.2	$228,000	2.3
Terrace Gardens	N/A	N/A	N/A	N/A
Sherwood Forest	N/A	N/A	N/A	N/A
Hunters Harbor/Long Point	N/A	N/A	N/A	N/A
Chartwell	$99.5	$192.0	$817,000	9.7
Shore Acres	N/A	N/A	N/A	N/A
Mt. Tabor Rd - Patuxent	$24.6	$46.2	$191,000	2.3
Patuxent Manor	$20.7	$44.9	$203,000	2.3

TABLE 30
Cost per EDU of Cluster Treatment with Direct Discharge

Study Area	Number of EDUs	Total Capital Cost per EDU	Total NPV per EDU	Annual O&M per EDU	EUAC per EDU
Riverdale	1290	N/A	N/A	N/A	N/A
Arden on the Severn	654	$36,800	$69,200	$348	$3,490
Terrace Gardens	718	N/A	N/A	N/A	N/A
Sherwood Forest	694	N/A	N/A	N/A	N/A
Hunters Harbor/Long Point	1808	N/A	N/A	N/A	N/A
Chartwell	2880	$34,600	$66,800	$284	$3,370
Shore Acres	881	N/A	N/A	N/A	N/A
Mt. Tabor Rd - Patuxent	362	$68,000	$128,000	$528	$6,430
Patuxent Manor	509	$40,600	$88,200	$399	$4,440

Table 31 summarizes treatment costs for cluster treatment using land application and direct discharge alternatives and compares it with the County costs of treatment based on the $7050 capital connection fee and annual user charges of $385. For some communities, cluster treatment may prove to be the more cost-effective alternative depending on the soil suitability for land application or availability of a direct discharge option.

TABLE 31
Comparison of Cluster Treatment O&M Costs and EUAC with WRF Treatment Costs

	Annual O&M per EDU			EUAC per EDU		
Study Area	Cluster Treatment with Land Application	Cluster Treatment with Direct Discharge	Additional Treatment Capacity - Sewer Extension*	Cluster Treatment with Land Application	Cluster Treatment with Direct Discharge	Additional Treatment Capacity - Sewer Extension*
Riverdale	N/A	N/A	$385	N/A	N/A	$1,600
Arden on the Severn	$262	$301	$385	$1,310	$1,620	$1,600
Terrace Gardens	$214	N/A	$385	$1,150	N/A	$1,600
Sherwood Forest	$202	N/A	$385	$1,130	N/A	$1,600
Hunters Harbor/Long Point	N/A	N/A	$385	N/A	N/A	$1,600
Chartwell	$150	$229	$385	$660	$1,080	$1,600
Shore Acres	$184	N/A	$385	$848	N/A	$1,600
Mt. Tabor Rd - Patuxent	$463	$400	$385	$3,050	$2,510	$1,600
Patuxent Manor	$344	$344	$385	$1,330	$1,790	$1,600

*Based on $7050 capital cost/EDU, and $585/EDU/yr required for each sewer connection

Analysis of Cost Relationships

Table 32 summarizes treatment costs for each alternative considered by study area using EUAC. The cluster treatment costs represent the lowest cost of treatment for each disposal method evaluated, and the cost of sewer extensions were summarized with and without the cost of additional treatment capacity. A 75 percent confidence interval was also applied to the costs to generate a high and low cost for each treatment alternative. The average costs were used as the basis for the initial phase of countywide extrapolation.

TABLE 32
Comparison of Treatment Alternatives using EUAC per EDU

	EUAC / EDU				
Study Area	**Sewer Extension**	**Sewer Extension with Additional WRF Treatment***	**Cluster Treatment**	**OSDS Upgrade (Low)**	**OSDS Upgrade (High)**
Riverdale	$2,100	$3,200	$2,700	$2,700	$4,800
Arden	$1,800	$3,000	$3,000	$2,700	$4,800
Terrace Gardens	$770	$1,900	$1,900	$2,700	$4,800
Sherwood Forest	$4,500	$5,700	$5,000	$2,700	$4,800
Gingerville	$2,500	$3,700	N/A	$2,700	$4,800
Hunters Harbor/Long Point	$2,300	$3,500	N/A	$2,700	$4,800
Chartwell	$2,100	$3,300	$2,800	$2,700	$4,800
Shore Acres	$2,300	$3,400	$3,000	$2,700	$4,800
Mt. Tabor Rd - Patuxent	$4,000	$5,200	$6,200	$2,700	$4,800
Patuxent Manor	$3,700	$4,900	$3,800	$2,700	$4,800
Average	**$2,607**	**$3,780**	**$3,550**	**$3,750**	
75% Confidence Interval High	$3,046	$4,219	$3,989	$4,189	
75% Confidence Interval Low	$3,046	$4,219	$3,989	$4,189	

*Additional WRF treatment estimated at $7,050 capital connection fee and $585 annual user charge.

The study area costs were analyzed for relationships that might prove useful in extrapolating the costs on a countywide basis and in developing an implementation plan for OSDS treatment. The EUACs were used as the basis for the analysis.

Figure 11 compares the EUAC per EDU costs of sewer extension to OSDS upgrades. Based on the life-cycle cost analysis, the cost of extending the sewerage infrastructure to capture flows from the onsite systems was generally less expensive. A strong linear relationship did not exist in terms of the unit cost of sewer extension in relation to distance from the existing facilities. The inclusion of treatment costs suggests that there is a threshold distance at which the onsite system upgrades would become more feasible.

Figure 12 examined the potential economies of scale that could result when applying each alternative to communities of increasing size. Again the relationships were not very strong suggesting that several site specific factors would influence the costs more than distance to sewer or community size alone.

Figure 13 revealed that OSDS density was a much stronger factor in the cost to provide treatment to a given community onsite system. Figure 14 provides the same analysis with the cost of capitalizing additional treatment at each facility removed. The cost density relationship of the land application and direct discharge options for cluster treatment facilities were plotted separately to demonstrate the cost difference in the two options in the study areas where both options were available. Density did not appear to differentiate the two options, but rather the site specific distance to the direct discharge point and the proximity to suitable soils for land application were the more dominant factors in the cost of each alternative.

Figures 15 compares all three options with respect to distance to sewer and Figure 16 provides a more detailed look at the relationship of treatment cost to sewer distance for communities with an average distance of less than 16,000 feet to existing sewers.

FIGURE 11
Comparison of EUAC per EDU Cost vs. Distance to Sewer for OSDS Upgrades and Sewer Extension Costs with and without WRF Treatment Costs

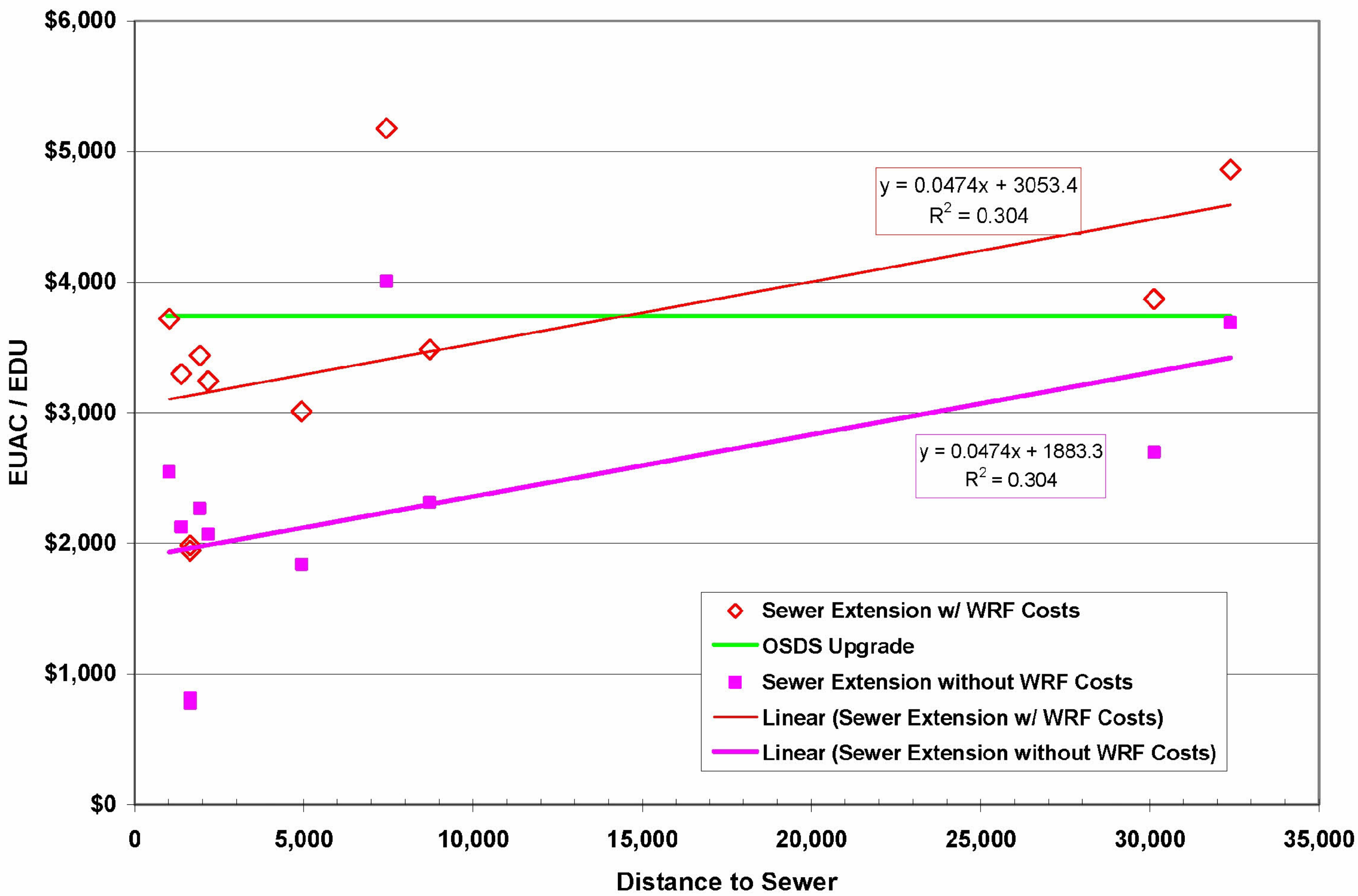


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FIGURE12
EUAC per EDU vs. Number of OSDS in Study Area

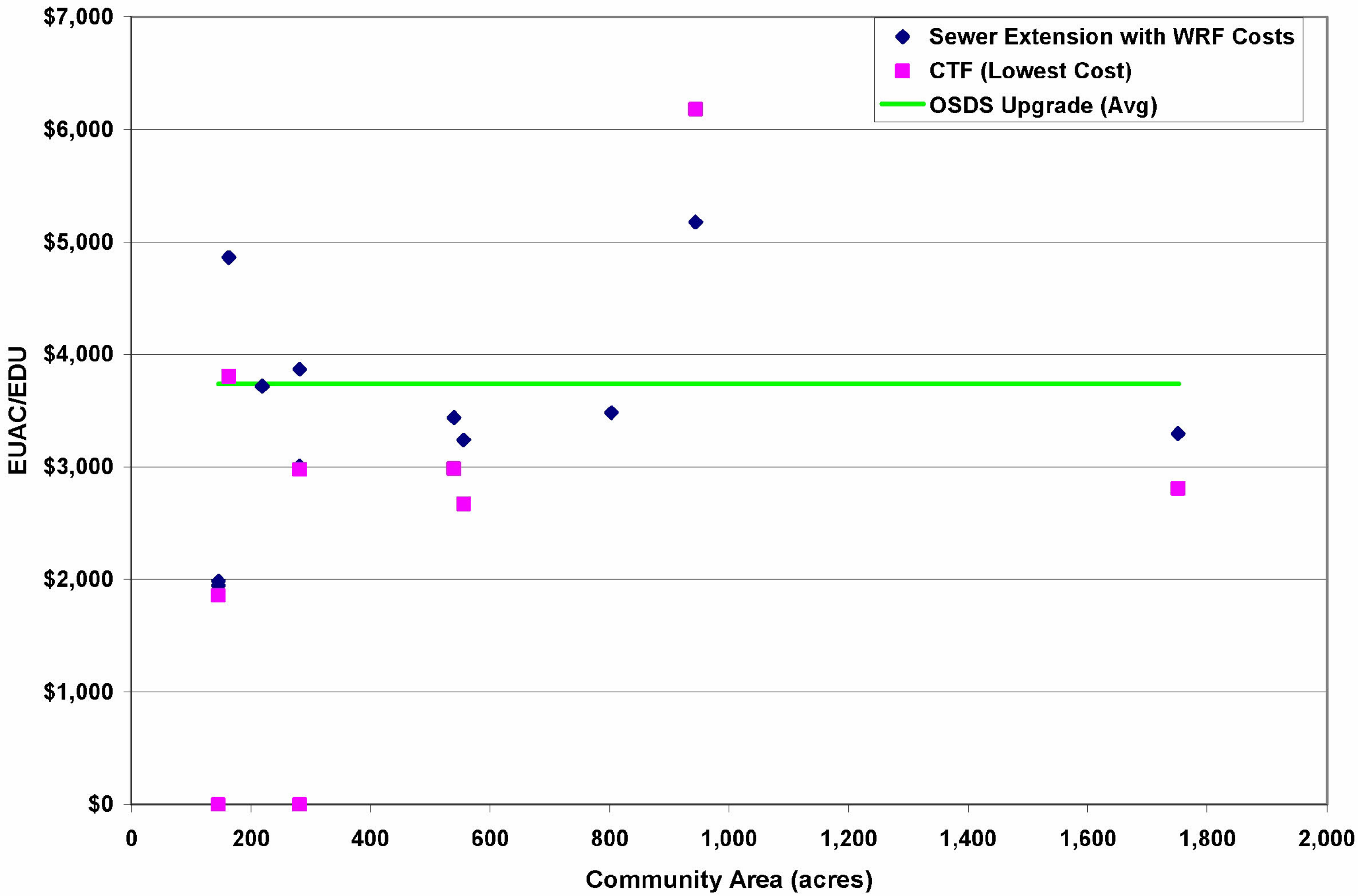

FIGURE 13
Treatment Cost (EUAC per EDU) vs. OSDS Density with WRF Treatment Costs for Sewer Extensions

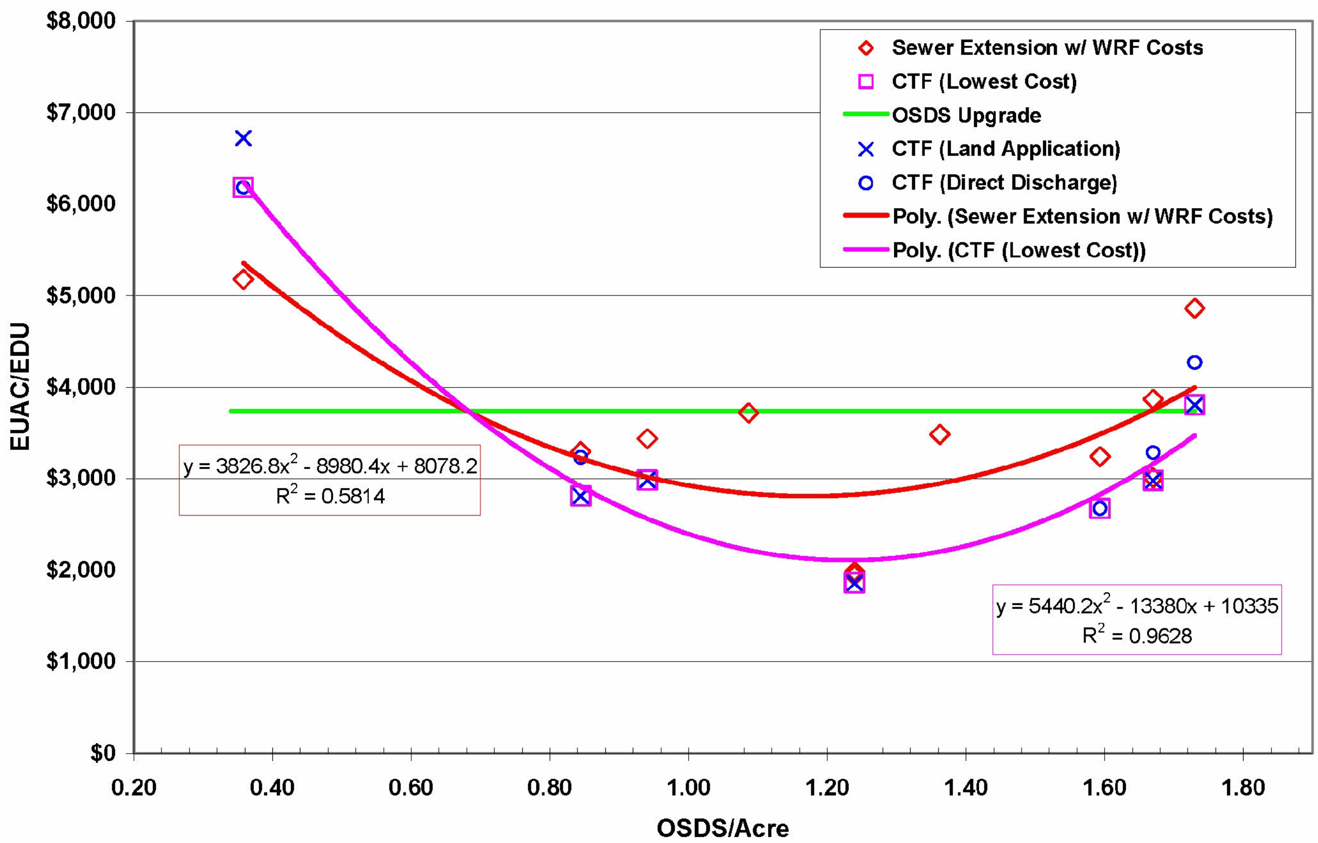

FIGURE 14
Treatment Cost (EUAC per EDU) vs. OSDS Density without WRF Treatment Costs for Sewer Extensions

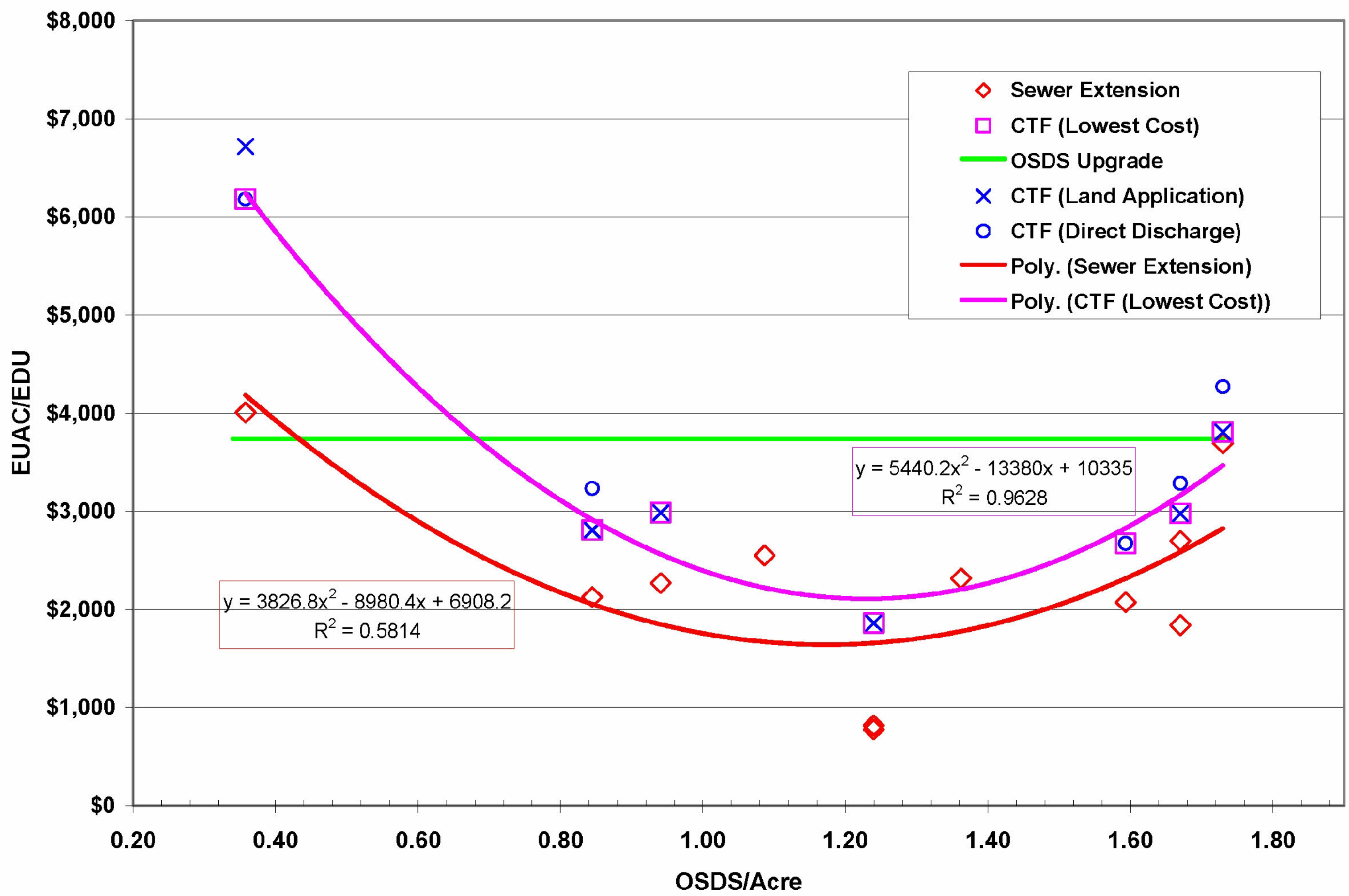

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FIGURE 15
Treatment Cost (EUAC) per EDU vs. Distance to Sewer without WRF Treatment Costs

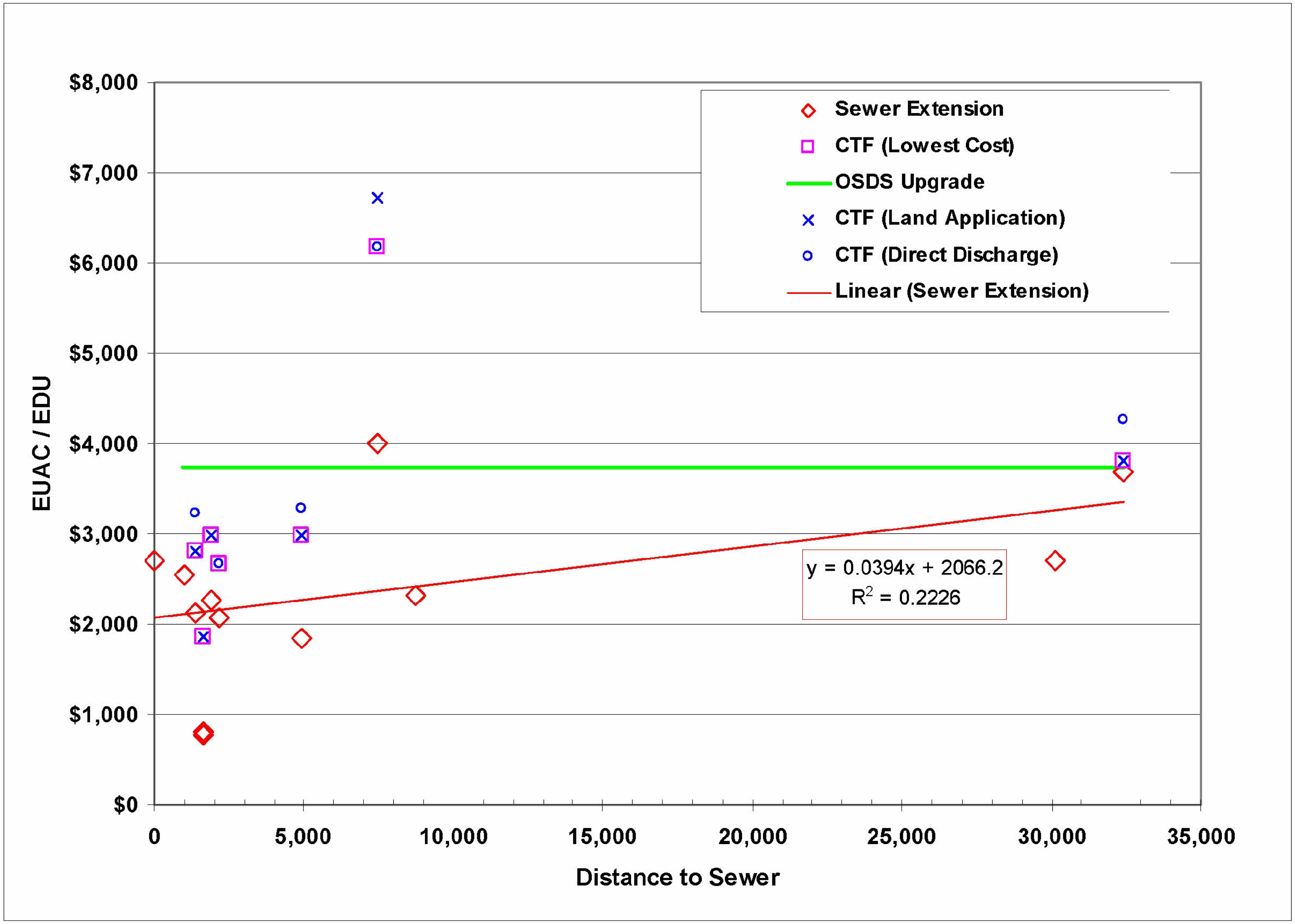

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FIGURE 16
Treatment Cost (EUAC) per EDU vs. Distance to Sewer with WRF Treatment Costs

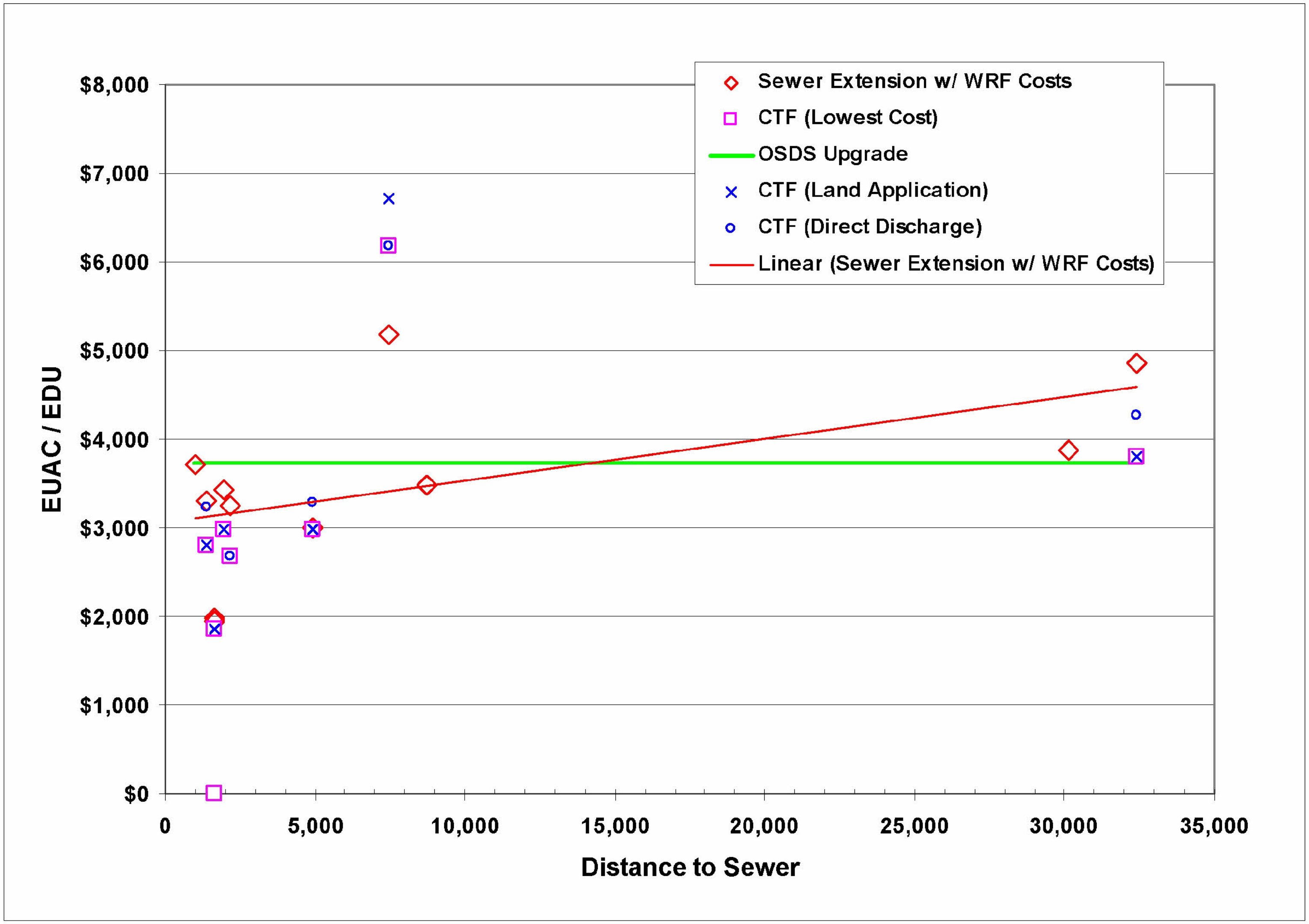

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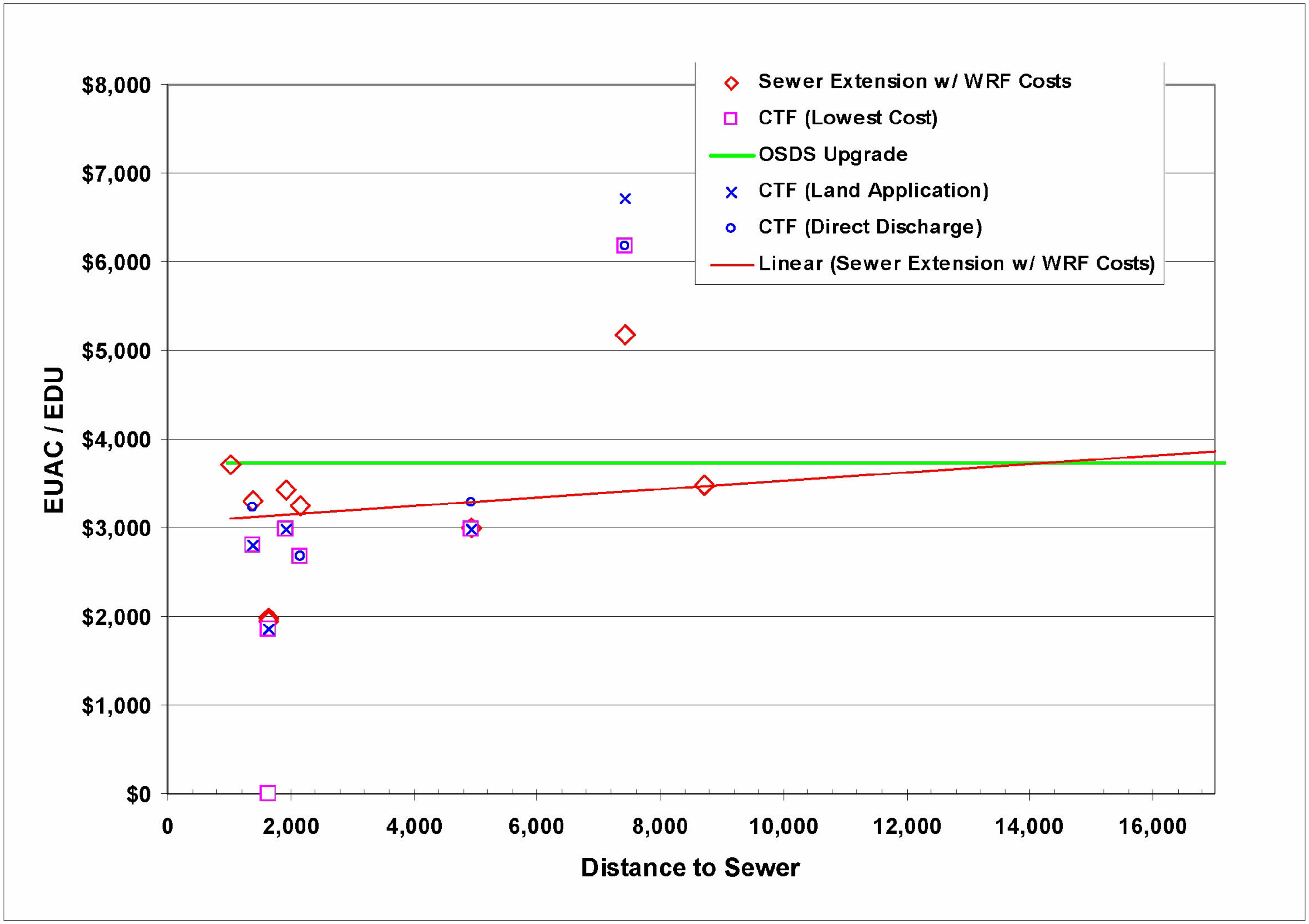
FIGURE 17
Comparison of EUAC per EDU vs. Distance to Sewer <17,000ft with WRF Treatment Costs



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Preliminary Countywide Cost Projections

Based on the study area costing analysis, the initial countywide extrapolation was performed using the average treatment costs summarized in Figures 18 and 19. Figures 20A and 20B provide a breakdown of the individual components of the EUAC costs. These costs have incorporated the recent Maryland energy cost increases through May 2007. The average cost of treatment was applied on a unit-EDU basis to extrapolate the cost by:

- Planned Sewer Service Type (Figures 21 and 22, and Tables 33 and 34)
- Planned Sewer Service Area (Table 35)
- Priority Rank (Tables 36 and 37)

FIGURE 18
Initial Capital Cost per EDU for Each Treatment Alternative with Additional WRF Capacity Shown

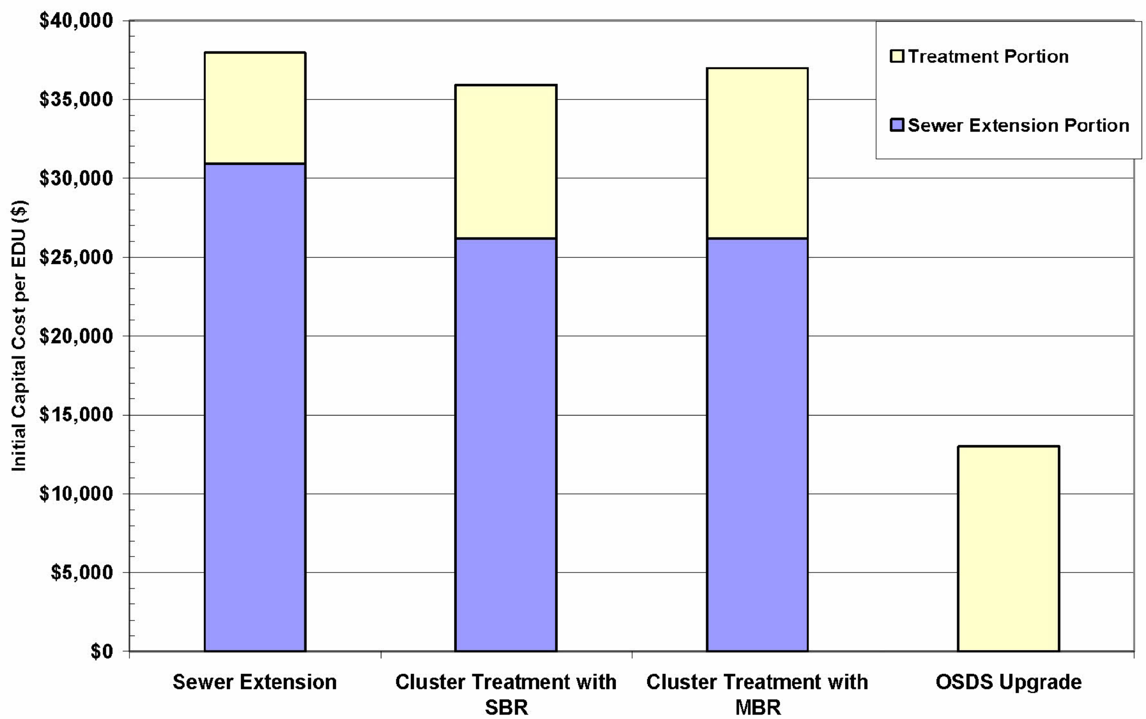

FIGURE 19
EUAC per EDU for Each Treatment Alternative with Additional WRF Capacity Shown

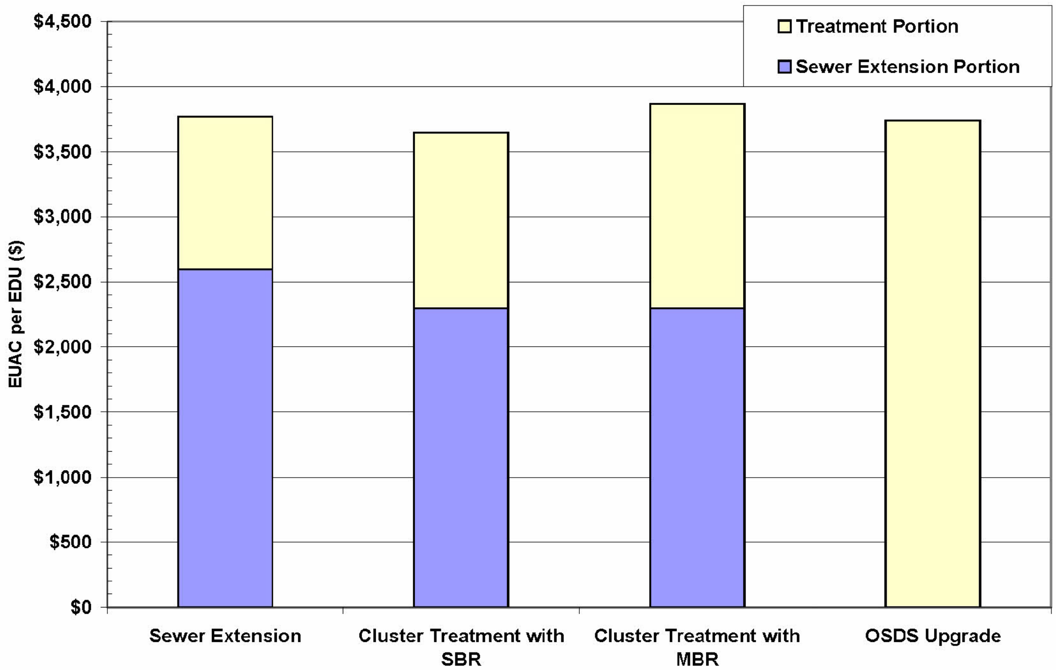

FIGURE 20A
EUAC per EDU for Each Treatment Alternative with Component Cost Breakdown

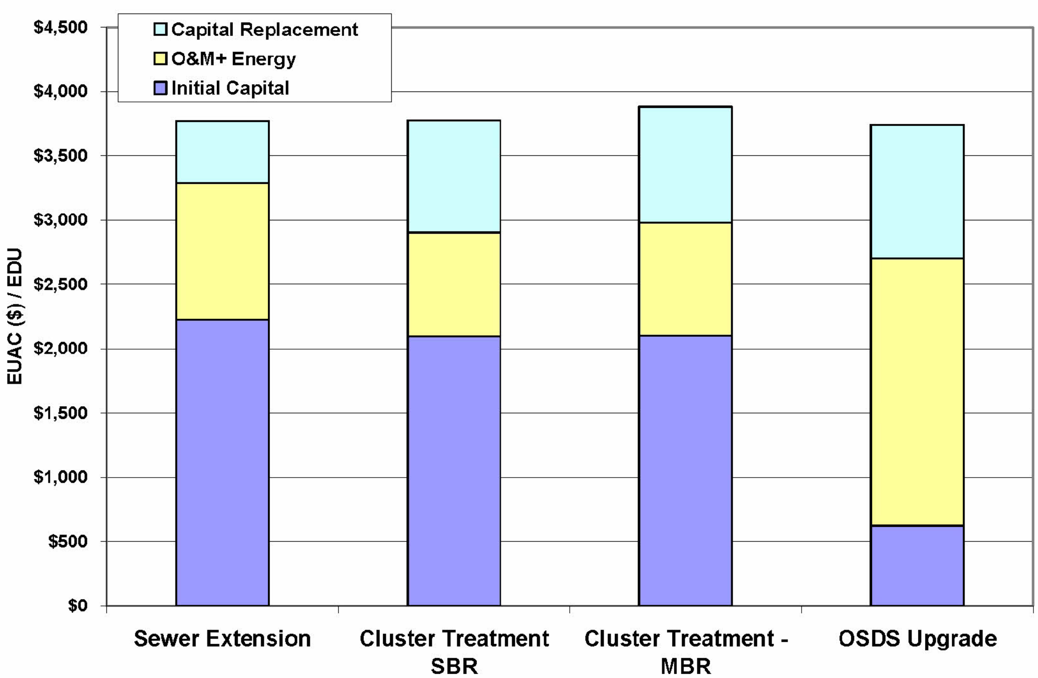

FIGURE 20B
EUAC per EDU for Each Treatment Alternative with Component Cost Breakdown with Energy Component

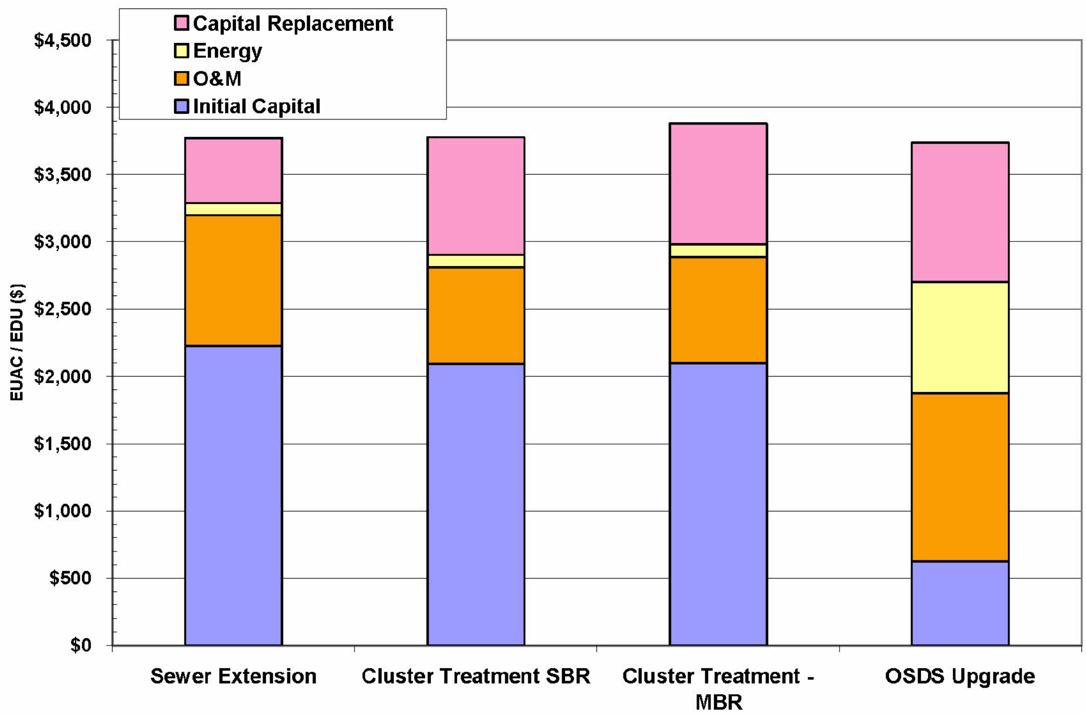

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FIGURE 21
EUAC by Planned Sewer Service Area Type

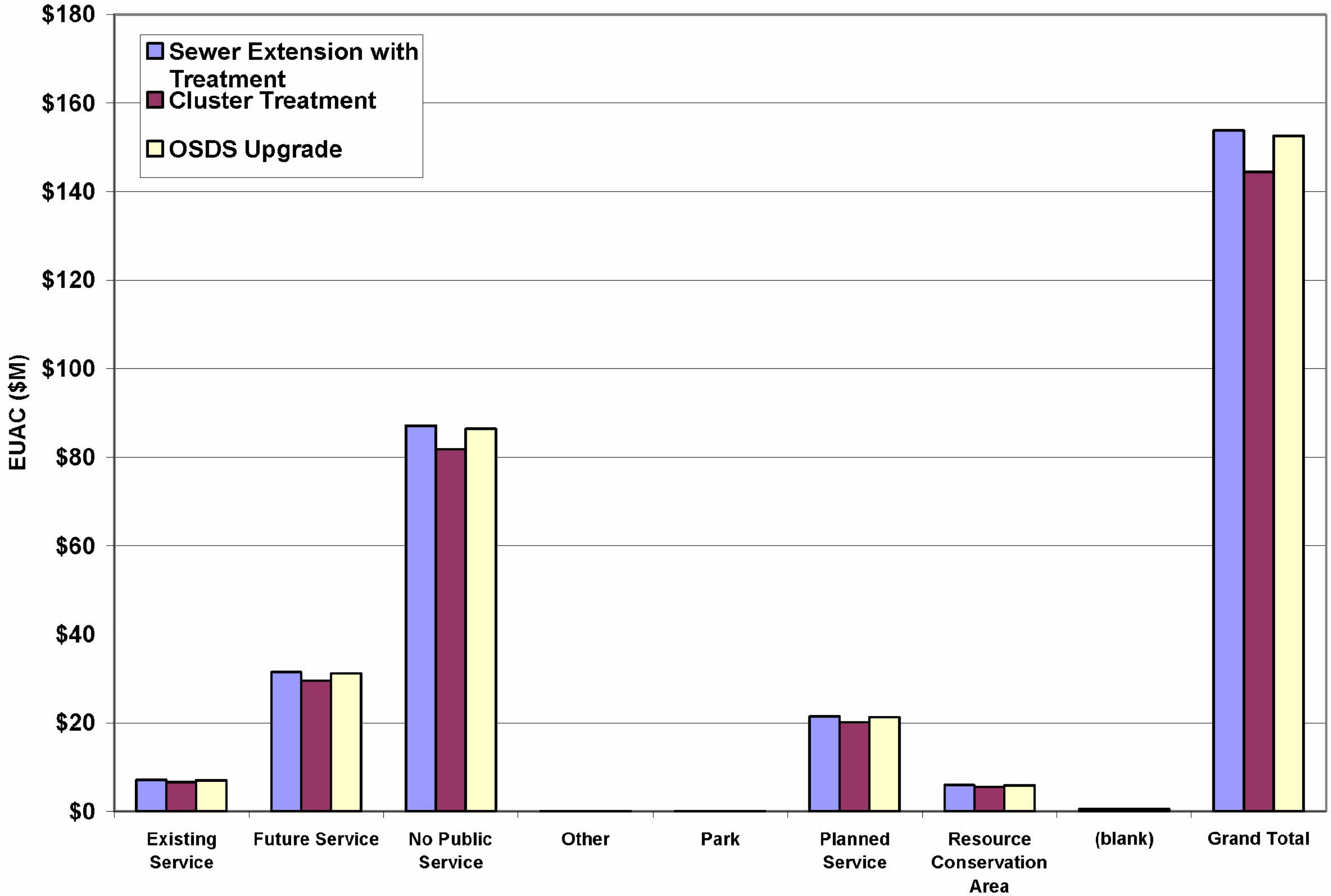

FIGURE 22
Initial Capital Cost by Planned Sewer Service Area Type

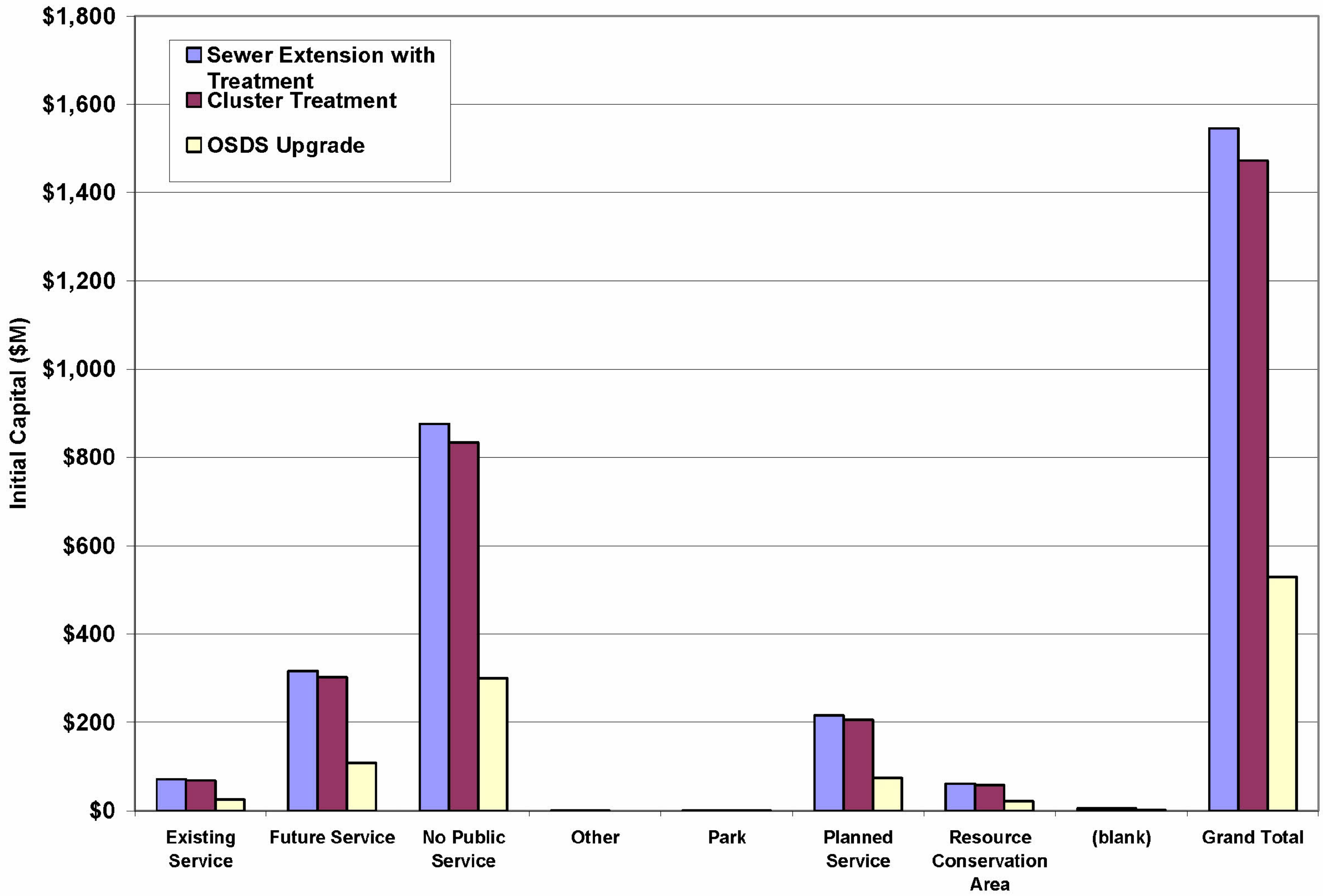

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TABLE 33
Countywide Estimates of Initial Capital Costs based on Average Cost / EDU by Planned Sewer Service Type

		Countywide Initial Capital Cost ($M)		
Planned Sewer Service Type	**EDUs** ***per EDU***	**Sewer Extension**	**Cluster Treatment**	**OSDS Upgrade**
	Unit Cost per EDU	*$38,000*	*$36,203*	*$13,000*
Existing Service	1,881	$71	$68	$24
Future Service	8,322	$316	$301	$108
No Public Service	23,041	$876	$834	$300
Other	18	$1	$1	$0
Park	22	$1	$1	$0
Planned Service	5,676	$216	$205	$74
Resource Conservation Area	1,584	$60	$57	$21
(blank)	140	$5	$5	$2
Grand Total	**40,684**	**$1,546**	**$1,473**	**$529**

*Includes $7050 capital cost/EDU, and $385/EDU/yr
**Based on least expensive cluster treatment option

TABLE 34
Countywide Estimates of EUAC Based on Average Cost / EDU by Planned Sewer Service Type

		EUAC ($M)		
Planned Sewer Service Type	**EDUs** ***per EDU***	**Sewer Extension**	**Cluster Treatment**	**OSDS Upgrade**
	Unit Cost per EDU	*$3,780*	*$3,550*	*$3,750*
Existing Service	1,881	$7	$7	$7
Future Service	8,322	$31	$30	$31
No Public Service	23,041	$87	$82	$86
Other	18	$0	$0	$0
Park	22	$0	$0	$0
Planned Service	5,676	$21	$20	$21
Resource Conservation Area	1,584	$6	$6	$6
(blank)	140	$1	$0	$1
Grand Total	**40,684**	**$154**	**$144**	**$153**

*Includes $7050 capital cost/EDU, and $385/EDU/yr
**Based on least expensive cluster treatment option

TABLE 34
Countywide Estimates of EUAC Based on Average Cost / EDU by Planned Sewer Service Type

		EUAC ($M)		
Planned Sewer Service Type	**EDUs *per EDU***	**Sewer Extension**	**Cluster Treatment**	**OSDS Upgrade**

TABLE 35
Countywide Estimates of EUAC Based on Average Cost / EDU by Sewer Service Area

		EUAC ($M)			Initial Capital ($M)		
Sewer Service Area	**EDUs**	**Sewer Extension**	**Cluster Treatment**	**OSDS Upgrade**	**Sewer Extension**	**Cluster Treatment**	**OSDS Upgrade**
Annapolis	3,201	$12.1	$11.4	$12.0	$121.6	$115.9	$41.6
Baltimore City	1,446	$5.5	$5.1	$5.4	$54.9	$52.4	$18.8
Bodkin Pt-Pinehurst	140	$0.5	$0.5	$0.5	$5.3	$5.1	$1.8
Broadneck	9,957	$37.6	$35.3	$37.3	$378.4	$360.5	$129.4
Broadwater	291	$1.1	$1.0	$1.1	$11.1	$10.5	$3.8
Cox Creek	2,513	$9.5	$8.9	$9.4	$95.5	$91.0	$32.7
Ft. George Meade	2	$0.0	$0.0	$0.0	$0.1	$0.1	$0.0
Maryland City	160	$0.6	$0.6	$0.6	$6.1	$5.8	$2.1
Mayo-Glebe Heights	104	$0.4	$0.4	$0.4	$4.0	$3.8	$1.4
Patuxent	892	$3.4	$3.2	$3.3	$33.9	$32.3	$11.6
Piney Orchard	17	$0.1	$0.1	$0.1	$0.6	$0.6	$0.2
Rose Haven	4	$0.0	$0.0	$0.0	$0.2	$0.1	$0.1
Rural	21,815	$82.5	$77.4	$81.8	$829.0	$789.8	$283.6
(blank)	142	$0.5	$0.5	$0.5	$5.4	$5.1	$1.8
Grand Total	40,684	$154	$144	$153	$1,546	$1,473	$529

**Includes $7050 capital cost/EDU, and $385/EDU/yr*

TABLE 36
Countywide Initial Capital Costs by OSDS Priority Rank

				Initial Capital ($M)			
Priority Score Category	EDUs	Total Nitrogen (lb/yr)	Percent *Unit Cost per EDU*	Sewer Extension	Sewer Extension w/ addt'l treatment	Cluster Treatment	OSDS Upgrade
			Unit Cost per EDU	*$27,963*	*$38,000*	*$36,203*	*$13,000*
1.0-1.5	13,186	225,869	26%	$369	$501	$477	$171
1.5-2.0	5,546	110,505	14%	$155	$211	$201	$72
2.0-2.5	5,696	133,136	18%	$159	$216	$206	$74
2.5-3.0	7,403	179,265	18%	$207	$281	$268	$96
3.0-3.5	4,383	111,573	11%	$123	$167	$159	$57
3.5-4.0	2,218	62,878	6%	$62	$84	$80	$29
4.0-4.5	1,534	41,433	4%	$43	$58	$56	$20
4.5-5.0	578	16,340	2%	$16	$22	$21	$8
Grand Total	**40,544**	**881,000**	**100%**	**$1,134**	**$1,541**	**$1,468**	**$527**

TABLE 37
Countywide Equivalent Uniform Annual Cost (EUAC) by OSDS Priority Rank

				EUAC ($M)			
Priority Score Category	EDUs	Total Nitrogen (lb/yr)	Percent *Unit Cost per EDU*	Sewer Extension *$2,607*	Sewer Extension w/ addt'l treatment *$3,780*	Cluster Treatment *$3,550*	OSDS Upgrade *$3,750*
			Unit Cost per EDU	*$2,607*	*$3,780*	*$3,550*	*$3,750*
1.0-1.5	13,186	225,869	26%	$34.4	$49.8	$46.8	$49.4
1.5-2.0	5,546	110,505	14%	$14.5	$21.0	$19.7	$20.8
2.0-2.5	5,696	133,136	18%	$14.8	$21.5	$20.2	$21.4
2.5-3.0	7,403	179,265	18%	$19.3	$28.0	$26.3	$27.8
3.0-3.5	4,383	111,573	11%	$11.4	$16.6	$15.6	$16.4
3.5-4.0	2,218	62,878	6%	$5.8	$8.4	$7.9	$8.3
4.0-4.5	1,534	41,433	4%	$4.0	$5.8	$5.4	$5.8
4.5-5.0	578	16,340	2%	$1.51	$2.18	$2.05	$2.17
Grand Total	**40,544**	**881,000**	**100%**	**$106**	**$153**	**$144**	**$152**

Nitrogen Load Projections for Treatment Alternatives

Policy Issues

During the analysis of the technical performance requirements, applicability, and cost of the treatment alternatives, several policy issues emerged that are important to consider in the selection of the future treatment approaches and implementation policies for the County's onsite systems. These issues generally fell into three categories:

- Permitting issues, including nutrient load caps and credits
- Chesapeake Bay Restoration Fund eligibility
- Compatibility with the County Comprehensive Plan and growth management

Permitting Issues

The assumptions for estimating nitrogen delivery to the County's receiving waters were shown to vary widely as the regulatory policy has evolved. This variance was found to have a significant bearing on both the load contributed by onsite systems in relation to other sources and ultimately affects the waste load allocation policy and "hook-up" credits that could be applied. Cluster treatment systems proved to be a cost-effective treatment technology, especially for communities above a size and density threshold, At present, it is unclear how this type of facility would be treated by MDE in the context of their evolving "bubble" permit framework.

This TM also discusses the need to create alternate and site-specific treatment approaches for areas with the following characteristics:

- Poor soil infiltration and high groundwater table
- Heath Department problem areas
- Long distance to sewer
- No direct discharge option because of shellfish restrictions

For example, regulatory and permitting implications could arise in the case where a membrane bioreactor (MBR)-based cluster treatment facility is the best option for areas with poor soils and a long distance to existing sewer service. In non-shellfish waters, a direct discharge option could be the most cost-effective treatment alternative, but it is unclear if permits would be granted under these cases. Similarly, cases will arise where sewer extension will be the most cost-effective treatment approach in Resource Conservation Areas and areas not presently designated for sewer service.

Given that challenging circumstances will exist in many cases, Anne Arundel County asked that innovative options be explored. The Hunters Harbor area exhibits all of the above-mentioned challenges and was evaluated for the potential use of wetland discharge and spray irrigation as the ultimate disposal option. The evaluation included the assumption that a cluster treatment facility would be employed and be capable of achieving effluent total nitrogen (TN) concentration in the 3-8mg/L range. Spray irrigation is a practice that is currently supported in the MDE *Guidelines for Land Treatment of Municipal Wastewaters*, and discharge to a treatment wetland could also be a viable option in certain cases. Using these options in combination with an MBR cluster treatment facility could also result in additional nutrient uptake (credits) that could be applied in the countywide strategy.

Nitrogen Delivery

A meeting was held with MDE to confirm current policy regarding nitrogen loading assumptions to be used for programs to comply with the nitrogen reduction requirements. MDE has provided the following statewide average septic load to surface water:

Septic Load = (People per Household) x (Loading rate in pounds TN per person / yr) x (Delivery Ratio) = 14.8 lbs TN / septic system per year where:

- People per Household = 2.6 persons/EDU
- Pounds TN per person / yr = 9.5 lbs/person/yr TN at edge of septic drain field (based on 78 gpcd at 40 mg/L TN)
- Delivery Ratio = 0.60

At a meeting on May 15, 2007, MDE provided their revised guidelines for estimating nitrogen delivery from onsite systems. The approach, as shown in Figure 23, allocates a delivery as a function of the distance to receiving water according to the following assumptions:

- 80 percent in critical areas (i.e., within 1,000 feet of tidal surface waters)
- 50 percent for areas outside of critical areas, but within 1,000 feet of surface waters (i.e. non-tidal surface waters)
- 30 percent all others

Application of this new framework resulted in a 38 percent reduction in the total estimated load from onsite systems—from 1.21 million pounds as calculated in the base case of TM 1 to 881,000 pounds per year under the new MDE assumptions. When compared to the cumulative number of OSDS within this range, it is readily apparent that the delivery ratio assumption within the first 300 feet of receiving water is critical to the overall management strategy for the OSDS systems. An expanded scientific basis for the delivery ratio assumptions should be sought. Table 38 summarizes the nitrogen loads that result from the delivery ratio approaches considered to date and compares the total load with that contributed by the wastewater reclamation facilities (WRFs) after conversion to Enhanced Nitrogen Removal (ENR).

FIGURE 23
Base Case Nitrogen Delivery Ratio Assumptions from TM1 and from MDE Policy as of 5/15/2007.

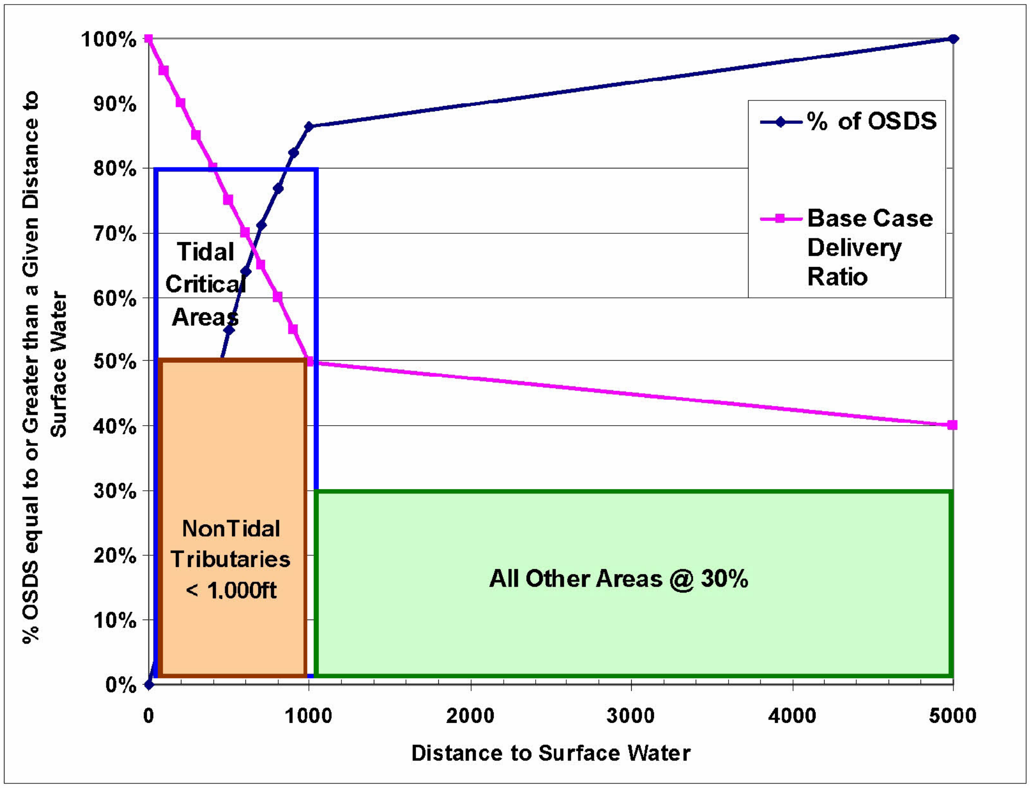

TABLE 38
Comparison of WRF and Septic Loads

WRF Loads	TN (lbs/yr)	TN (lbs/yr) after ENR upgrades
2005 WRF Load	747,865	631,854
Estimated Septic Load	TN (lbs/yr)	**TN (lbs/yr) after OSDS upgrades**
Base Case Task 1 TM (Figure E-4)	1,241,400	624,330
60% Uniform Delivery	959,000	482,328
Revised MDE Delivery (80/50/30)	881,000	443,221

Cost-effectiveness of Denitrifying Upgrades Versus Hookup to Sewer

The overall cost-effectiveness of each treatment approach in reducing nitrogen loads delivered to area receiving waters was analyzed on a unit cost per pound removal basis. The MDE 80/50/30 delivery ratio approach was applied to the effluent concentration for each treatment approach and applied to each OSDS in the county. The effluent concentrations were assumed to be 3 mg/L for the sewer extension alternative to reflect upgrading the WRFs to ENR. The MBR-based cluster treatment facilities used in the cost analysis were designed provide an effluent with 3 mg/L TN. The sequencing batch reactor (SBR) cluster systems would provide 8 mg/L to be consistent with MDE requirements for all treatment facilities above 5,000 gallons per day (gpd). The OSDS denitrification upgrades were estimated to provide 20 mg/L TN per MDE policy. The total cumulative delivered load and the total load reduction achievable are summarized in Table 39. The achievable reductions from this table were used to translate the average treatment cost for each alternative to a cost per pound removed. This is illustrated in Figures 24 and 25, along with the total achievable TN reduction.

TABLE 39
Comparison of Treatment Alternatives by Effluent Concentration, Delivered Load, and Achievable Countywide Reduction

	Sewer Extension and WRF	Cluster Treatment with SBR and Land Application	Cluster Treatment with MBR and Direct Discharge	OSDS Upgrade
Effluent N Concentration (mg/L)	3	8	3	20
Delivered TN	119,640	323,581	119,640	443,221
Achievable TN Reduction	761,360	557,419	761,360	437,779
Initial Capital Cost $/LB TN Removed	$2,030	$2,621	$1,977	$1,208
EUAC $/LB TN Removed	$201	$266	$207	$347

Note - Load estimates based on current MDE delivery ratio assumption - 80% for OSDS in Critical Area, 50% for OSDS within 1000' of receiving water, 30% for all other OSDS

This analysis indicated that on a per-unit removal basis, sewer extensions and cluster treatment approaches are more cost effective and are capable of obtaining a higher level of overall nitrogen removal than OSDS upgrades.

FIGURE 24
Estimated Nitrogen Load Reduction Achievable by Treatment Technology and Total Initial Capital Cost per lb. of Nitrogen Removed

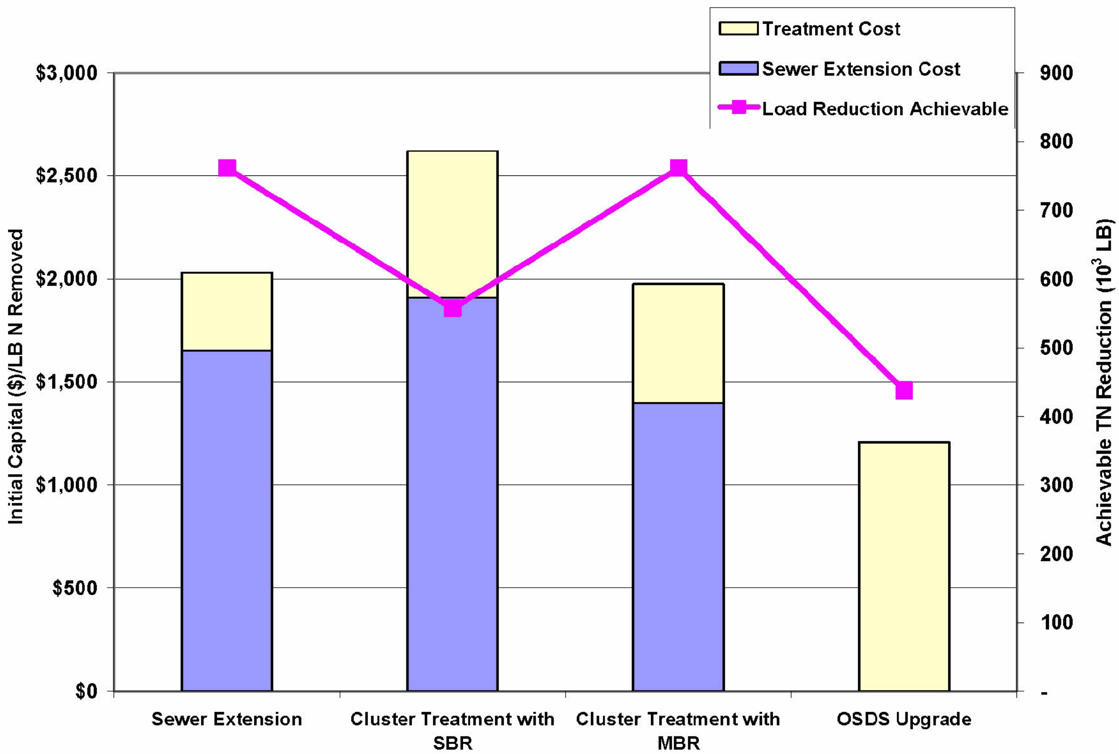

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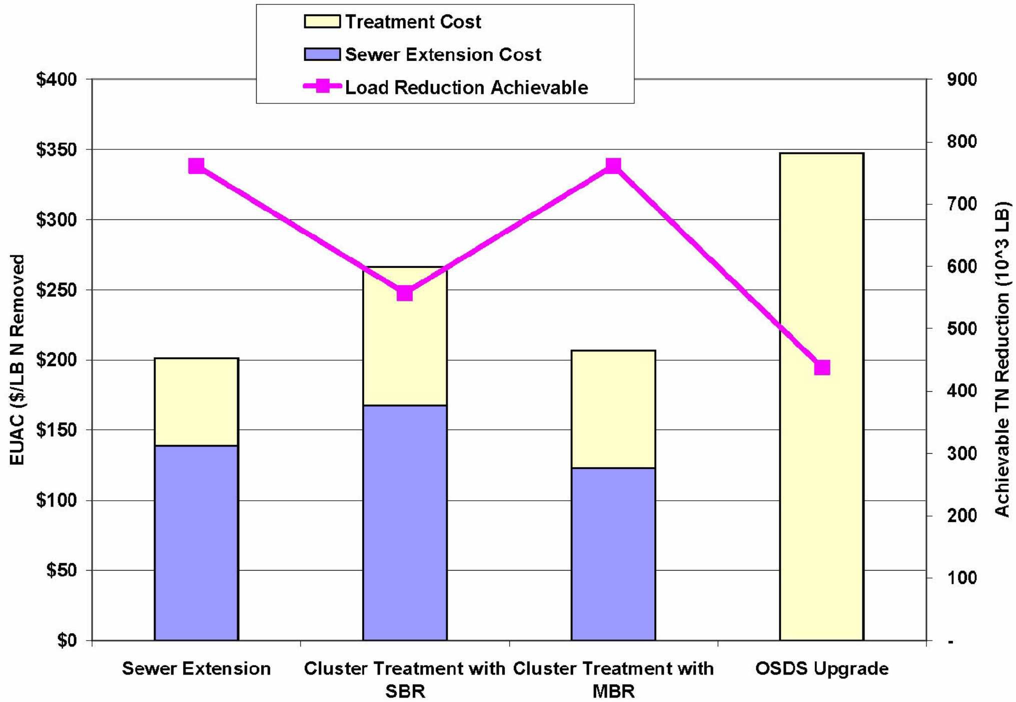
FIGURE 25
Estimated Nitrogen Load Reduction Achievable by Treatment Technology and Equivalent Uniform Annual Cost per lb. of Nitrogen Removed



Chesapeake Bay Restoration Fund Eligibility

The cost-benefit analysis indicated that cluster treatment and sewer extension alternatives are more effective in terms of life- cycle costs and nitrogen removal effectiveness. Presently, there is no conduit for Chesapeake Bay Restoration Funds to be used for connecting onsite systems to public sewers or to effective decentralized treatment practices such as cluster treatment facilities and treatment wetlands. Table 40 presents a basic credit scenario based on the revised MDE loading approach. Providing a sewer extension or cluster treatment facility to an existing OSDS area would result in a TN credit of 8 pounds/year.

TABLE 40
Summary of Conceptual Credits

	TN (lb/yr)	Delivered TN Load (lb/OSDS)
Existing Condition Estimated TN to Receiving Waters per OSDS (lb/yr) *	881,000	21.7
Delivered Load per OSDS converted to denitrification at 20 mg/L effluent quality (lb/yr)	443,221	10.9
Load per OSDS connected to sewer and WRF with ENR or MBR Cluster treatment facility (lb/yr)	119,640	2.9
Load Reduction beyond tributary strategy requirement, per OSDS connected to sewer or MBR cluster treatment (lb/yr)	323,581	8.0

* Current MDE delivery ratios as 80% for OSDS in Critical Area, 50% for OSDS within 1000' of receiving water, 30% for all other OSDS

Compatibility with the Comprehensive Plan and Growth Management

Many of the OSDS systems are located in the Resource Conservation Area or in areas where sewer service was not previously planned for in the County's comprehensive plan, potentially limiting the application of the most effective treatment technology. Growth management is an important issue to be considered in the overall nutrient management strategy for the County. It should be noted that the costs to provide treatment via sewer extensions and cluster treatment were sized to handle the ultimate build-out scenario in terms of capacity. Although the technologies were all very similar in terms of their annual life-cycle costs, they differed significantly in terms of their ability to provide nitrogen removal and their ability to accommodate growth with minimal additional nitrogen production. These issues will be considered in the next project phase.

TABLE 41
Countywide Estimates of Initial Capital Costs Based on Average Cost / EDU

		Countywide Initial Capital Cost ($M)		
Planned Sewer Service Type	**EDUs *per EDU***	**Sewer Extension**	**Cluster Treatment**	**OSDS Upgrade**
	Unit Cost per EDU	*$38,000*	*$36,203*	*$13,000*
Existing Service	1,881	$71	$68	$24
Future Service	8,322	$316	$301	$108
No Public Service	23,041	$876	$834	$300
Other	18	$1	$1	$0
Park	22	$1	$1	$0
Planned Service	5,676	$216	$205	$74
Resource Conservation Area	1,584	$60	$57	$21
(blank)	140	$5	$5	$2
Grand Total	**40,684**	**$1,546**	**$1,473**	**$529**

*Includes $7050 capital cost/EDU, and $385/EDU/yr

**Based on least expensive cluster treatment option

TABLE 42
Countywide Estimates of EUAC Based on Average Cost / EDU

		EUAC ($M)		
Planned Sewer Service Type	**EDUs *per EDU***	**Sewer Extension**	**Cluster Treatment**	**OSDS Upgrade**
	Unit Cost per EDU	*$3,780*	*$3,550*	*$3,750*
Existing Service	1,881	$7	$7	$7
Future Service	8,322	$31	$30	$31
No Public Service	23,041	$87	$82	$86
Other	18	$0	$0	$0
Park	22	$0	$0	$0
Planned Service	5,676	$21	$20	$21
Resource Conservation Area	1,584	$6	$6	$6
(blank)	140	$1	$0	$1
Grand Total	**40,684**	**$154**	**$144**	**$153**

*Includes $7050 capital cost/EDU, and $385/EDU/yr
**Based on least expensive cluster treatment option

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Attachments

Attachment-A - Petition Area Report Summary Data

Attachment B - Sewer Extension Design Schematics

Attachment C – Sewer Extension Cost Estimates

Attachment D –Cluster Treatment Facility Design Schematics

Attachment E –Cluster Treatment Facility Cost Estimates

Attachment F –Natural Treatment Systems Analysis

Attachment-A - Petition Area Report Summary Data

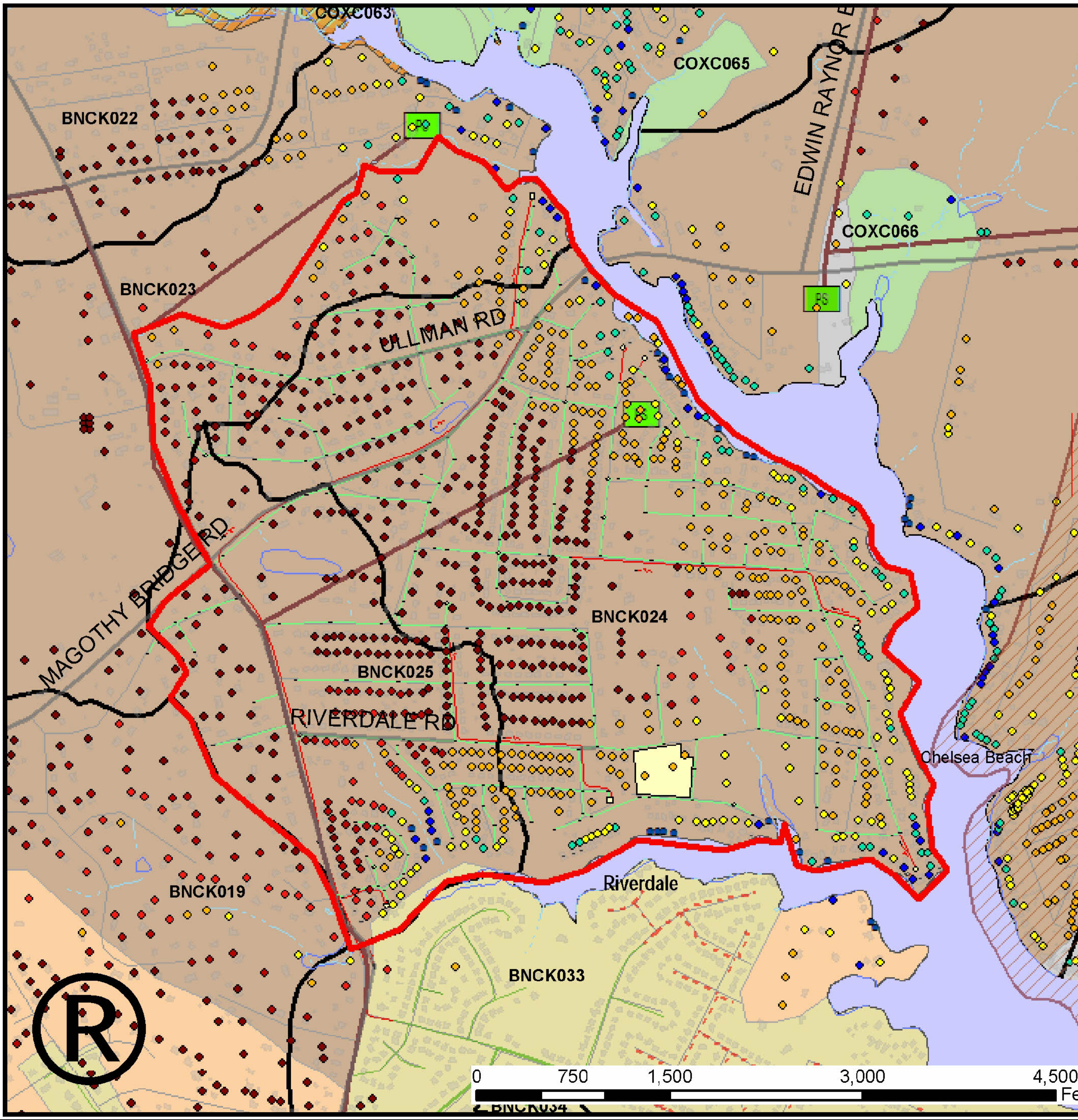
ID	Petition Area	Number of OSDS	Petition Area (ac)	EDUs	Current Flows (gpd @ADF)	Ultimate Flows (gpd @ADF)	Ultimate Flows (1,000 gpd @ADF)	AVE Dist to Sewer (ft)	Density (# of OSDS per acre)	Estimated Annual O&M Cost	Sewer Capital Cost (yr of Petition Report)	Adjusted 2007 Capital Cost	2007 Capital Cost per OSDS	2007 Annual Cost per EDU	2007 Capital Cost / EDU	Outlier
1	DEALE ROAD SEWER EXTENSION	36	109	374	76,450	93,600	94	849	0.33	$7,116	1,387,200	$ 1,621,590	$ 45,044	$ 22	$ 4,336	
2	SYLVAN SHORES SEWER PETITION	188	46	202	50,500	50,500	51	275	4.09	n/a	$1,430,000	$ 1,651,048	$ 8,782		$ 8,174	
3	WOODHOLME CIRCLE SEWER EXT	48	24	54	13,500	13,500	14	335	2.04	$1,575	$1,331,744	$ 1,353,908	$ 28,206	$ 30	$ 25,072	
4	WETHERIDGE ESTS SEWER EXT	11	11	13	3,250	3,250	3	440	0.98	n/a	$218,500	$ 250,915	$ 22,810		$ 19,301	
5	HANOVER ROAD SEWER PETITION	19	193	43	4,000	10,750	11	1,756	0.10	$4,793	$2,520,820	$ 2,562,774	$ 134,883	$ 113	$ 59,599	
6	EDGEWATER BEACH W & S PET	149	50	194	27,250	48,500	49	1,068	2.98	$9,850	$3,725,945	$ 4,130,039	$ 27,718	$ 56	$ 21,289	
7	LOCUST GROVE SEWER PETITION	15	95	85	15,750	21,250	21	984	0.16	$21,170	$2,955,618	$ 2,944,036	$ 196,269	$ 248	$ 34,636	
8	OLD TELEGRAPH RD WW PETITION	7	3	8	2,000	2,000	2	322	2.33	$4,035	$1,684,130	$ 1,774,428	$ 253,490	$ 531		$ 221,803
9	SHADY REST ROAD WASTEWATER PET	15	34	20	5,000	5,000	5	884	0.44	$1,550	$916,100	$ 942,411	$ 62,827	$ 80	$ 47,121	
10	CARRS MANOR WW EXTENSION	17	7	30	4,000	7,500	8	562	2.62	$2,682	$2,247,870	$ 2,239,062	$ 131,710	$ 89	$ 74,635	
12	ST BEES DRIVE	26	10	29	7,250	12,000	12	2,494	2.60	$3,725	$606,200	$ 653,111	$ 25,120	$ 138	$ 22,521	
13	NORTH PATUXENT RD	37	30	41	9,250	10,250	10	1,391	1.23	$2,510	$432,250	$ 513,358	$ 13,875	$ 73	$ 12,521	
14	DAVID VICTORIA LA	6	15	18	1,500	4,500	5	646	0.39	$336	$293,573	$ 303,192	$ 50,532	$ 19	$ 16,844	
15	SABRINA PARK SANITARY SEWER	81	45	87	10,250	21,750	22	834	1.80	$3,650	$1,061,103	$ 1,428,826	$ 17,640	$ 56	$ 16,423	

			Petition Area Report Summary Data												
ID	Petition Area	Date of Study	Components	Annual Cost	Capital Cost	O & M Cost	Land Use Type Breakdown (zoning)	EDU_S	EDUs from Report	AVG_GALLON	Current Flows	Ultimate Flows	Petition Report Delineation Matches AACO GIS	Area from Petition Report (ac)	Area from AACO GIS (ac)
1	DEALE ROAD SEWER EXTENSION	Oct-03	Grinder Pumps with Low Pressure Sewer	$7,115.68	$1,387,200	pipe & $50 per grinder pump	MC, R-1, R-2, RCA, LDA, OS	Residential=76 EDU's Commercial=34 Acres	EDU's Commercial=34	21,000	Average Daily Flow	Average Daily Flow	N	109	37.0
2	SYLVAN SHORES SEWER PETITION	Feb-04	grinder pumps with low pressure sewer and gravity sewer mains	Not provided in report	$1,525,000 Sewer-	Not provided in report	R-2, R-5	200	202 EDU's	50,000	Average Daily Flow	Average Daily Flow	Y	46	46.85
3	WOODHOLME CIRCLE SEWER EXT	Current	Complete Gravity Sewer System	$1,575.00	$1,331,744	$0.50 per linear foot for pipe	R-2	54	54 EDU's	13,500	Average Daily Flow	Average Daily Flow	Y	23.5	23.50
4	WETHERIDGE ESTS SEWER EXT	Mar-04	Grinder Pumps with Low Pressure Sewer	Not provided in report	$218,500	Not provided in report	Residential	13	13 EDU's	3,250	Average Daily Flow	Average Daily Flow	Y	11.27	13.00
5	HANOVER ROAD SEWER PETITION	Current	Gravity Sewer System & 2 grinder pumps with Low Pressure Sewer	$4,792.50	$2,520,820	pipe, $320 per grinder pump	W-1, O.S.	41	43 EDU's	10,250	Average Daily Flow	Average Daily Flow	N	193.47	199.00
6	EDGEWATER BEACH W & S PET	Jul-04	recommended Sewage grinder pumps with low pressure sewer	$9,850.00	$3,725,945	pump, $150 per duplex grinder pump, no cost	R-1, R-2, LDA	194	194 EDU's	48,500	Average Daily Flow	Average Daily Flow	N	50	50.00
7	LOCUST GROVE SEWER PETITION	Dec-06	station and forcemain & grinder pumps with Low Pressure Sewer	$21,170.00	$2,955,618	gravity sewer, $1.00 per linear foot for pressure	R-2, RLD, RCA, OS	80	85 EDU's	20,000	Average Daily Flow	Average Daily Flow	Y	95	95.00
8	OLD TELEGRAPH RD WW PETITION	Sep-05	Gravity Sewer System with pumping station and FM	$4,035.00	$1,684,130	$0.50 per linear foot for pipe, $3,285 for SPS	R-2, W-1	8	8 EDU's	2,000	Average Daily Flow	Average Daily Flow	N	3	4.79
9	SHADY REST ROAD WASTEWATER PET	Feb-06	Gravity Sewer System & 2 grinder pumps with Low Pressure Sewer	$1,550.00	$916,100	pipe, $250 per grinder pump	R-1, LDA	19	20 EDU's	5,000	Average Daily Flow	Average Daily Flow	Y	34	38.00
10	CARRS MANOR WW EXTENSION	Dec-06	Gravity Sewer System with pumping station and FM	$2,682.00	$2,247,870	$0.50 per linear foot for pipe, $1,182 for SPS	R-10	16	30 EDU's	250	Average Daily Flow	Average Daily Flow	Y	6.5	1.42
12	ST BEES DRIVE	Nov-04	Gravity Sewer System with pumping station and FM	$3,725	$606,200	$0.25 per linear foot for pipe, $2,500 for SPS	Residential	29	29 EDU's	7,250	Average Daily Flow	Average Daily Flow	Y	10	10.00
13	NORTH PATUXENT RD	May-03	Grinder pumps with Low Pressure Sewer	$2,509.60	$432,250	pipe, $50 per simplex grinder pump, $100 per	R-2, R-5	41	41 EDU's	10,250	Average Daily Flow	Average Daily Flow	Y	30	29.00
14	DAVID VICTORIA LA	Dec-05	Water distribution system & Gravity Sewer	$336.00 for sewer	water $293,573 for	$0.24 per linear foot for pipe (sewer)	R-5	10	18 EDU's	2,500	Average Daily Flow	Average Daily Flow	Y	15.22	15.22
15	SABRINA PARK SANITARY SEWER	Jan-98	Gravity Sewer System & grinder pumps with Low Pressure Sewer	$3,650.00	$1,061,103	$0.50 per linear foot for pipe	Residential	78	87 EDU's	19,500	Average Daily Flow	Average Daily Flow	Y	45	45.00

ID	Petition Area	Petition Summary and Status Information							
		Date of Study	GIS_ID	Consultant	CONTRACT_NO	Design Drawings (Yes / No)	Level of Study (Concept, Schematic Design, etc.)	STATUS	OLD_STATUS
1	DEALE ROAD SEWER EXTENSION	Oct-03	481	Harms	S802001	Yes	Now in design phase	Design	Petition
2	SYLVAN SHORES SEWER PETITION	Feb-04	732	Dewberry & Davis	Y514229 Z533231	No	Final Schematic Design Report	Petition	Capital Proj
3	WOODHOLME CIRCLE SEWER EXT	Current	766	Harms	S803601	Yes	Now in design phase	Cap. Proj.	Capital Proj
4	WETHERIDGE ESTS SEWER EXT	Mar-04	769	Dewberry & Davis	Z533234	No	Final Schematic Design Report	Petition	Concept
5	HANOVER ROAD SEWER PETITION	Current	797	Harms	S802101	Yes	awaiting award to begin construction	Cap. Proj.	Capital Proj
6	EDGEWATER BEACH W & S PET	Jul-04	843	ARRO Consulting	Y514200	No	Draft Schematic Design Report	Petition	Capital Proj
7	LOCUST GROVE SEWER PETITION	Dec-06	923	Harms	Z533238	No	Final Schematic Design Report	Petition	Capital Proj
8	OLD TELEGRAPH RD WW PETITION	Sep-05	934	ARRO Consulting	Concept	No	Schematic Design Report	Petition	Capital Proj
9	SHADY REST ROAD WASTEWATER PET	Feb-06	1023	ARRO Consulting	Concept	No	Schematic Design Report	Petition	Capital Proj
10	CARRS MANOR WW EXTENSION	Dec-06	1131	ARRO Consulting	Concept	No	Schematic Design Report	Petition	Petition
12	ST BEES DRIVE	Nov-04		Century Engineering	Z533236	No	Schematic Design Report	Inactive	Petition
13	NORTH PATUXENT RD	May-03		Harms	Z533228	No	Final Schematic Design Report	Petition	Petition
14	DAVID VICTORIA LA	Dec-05		Harms	Y514235 Z533243	No	Final Schematic Design Report	Petition	Petition
15	SABRINA PARK SANITARY SEWER	Jan-98		RK&K	Z533207	Yes	Design Drawings created January 2000	Design	Petition

ID	Petition Area	Notes: Confirm Peition area boundary w/ county GIS parcel delineation	Description of Report Details	Notes
1	DEALE ROAD SEWER EXTENSION	Acreage from report for Deale Rd. Petition = 98 Ac. Acreage from report for Highview Petition = 11 Ac. Total Area = 109 Ac. The Petition Area boundary shown in County's GIS appears incorrect. The boundary continues southward covering all of the Herrington Harbor Marina and Highview on the Bay. It also was extended northward along Rockhold Creek Road. A PDF file showing the limits of new sewer service is provided.	Schematic Design with detailed cost estimate, all properties to be served by grinder pump & Low Pressure Sewer system	Residential flows based upon dwelling units (EDU's). Commercial flows based upon acreage. EDU field calculated from flow projection
2	SYLVAN SHORES SEWER PETITION	Acreage from report = 46Ac. Petition Area boundary shown in County's GIS system mathces that shown in the report.	Schematic Design with detailed cost estimate, abandon private water system and replace with County system. New grinder pumps with Low Pressure & Gravity Sewer	
3	WOODHOLME CIRCLE SEWER EXT	Acreage from design drawings = 23.50Ac. Petition Area boundary shown in County's GIS system matches that shown in the design drawings.	Complete Gravity Sewer System	Provided information based on current design drawings
4	WETHERIDGE ESTS SEWER EXT	No acreage was provided in the schematic report. Acerage from Maryland Real Property = 11.27 Ac. Petition Area boundary shown in County's GIS system appears to match that shown in the report.	Low pressure sewer system to existing pump station	
5	HANOVER ROAD SEWER PETITION	Acreage of Parcels being served under sewer extension contract = 193.47 Ac. Petition Area boundary shown on County's GIS looks very close to the properties being connected, but is not exact. A PDF file showing the limits of new sewer service is provided.	Gravity Sewer System & 2 grinder pumps with Low Pressure Sewer	Provided information based on current construction drawings. Current flows based upon existing dwellings. Ultimate flows based on build-out.
6	EDGEWATER BEACH W & S PET	Acreage from report=50Ac. Petition Area boundary shown on County's GIS system appears to be larger than the one in the schematic design report. The report boundary stops at Main Street, while the GIS boundary extends past Main Street to include Chestnut Street.	Schematic Design with detailed cost estimate, all properties recommended to be served by grinder pump & Low Pressure Sewer system, also includes water distribution system	
7	LOCUST GROVE SEWER PETITION	Acreage from report = 95Ac. Petition Area boundary shown in County's GIS system mathces that shown in the report.	Schematic Design with detailed cost estimate, Gravity Sewer System with pumping station and forcemain & grinder pumps with Low Pressure Sewer	Costs shown are to serve the Petition Area only, not including the surrounding properties. Current flows based upon existing dwellings. Ultimate flows based on build-out.
8	OLD TELEGRAPH RD WW PETITION	Acreage from report for Petition Area = 3 Ac. Petition Area boundary shown on the County's GIS system appears to be larger than the one shown in the schematic design report. The report boundary does not encompass all of Parcel 124.	Schematic Design with detailed cost estimate, Gravity Sewer System with pumping station and forcemain	Costs shown are from the report's recommended service alternative
9	SHADY REST ROAD WASTEWATER PET	Acreage from report = 34Ac. Petition Area boundary shown in County's GIS system appears to match that shown in the report. Maryland Real Property information confirms the report acreage of 34 Acres.	Schematic Design with detailed cost estimate, gravity sewer system and 2 grinder pumps with low pressure sewer	Costs shown are from the report's recommended service alternative
10	CARRS MANOR WW EXTENSION	Acreage from report = 6.5Ac. Petition Area boundary shown in County's GIS system appears to match that shown in the report. Maryland Real Property information for the Petition Area properties totals 5.54 Acres.	Schematic Design with detailed cost estimate, Gravity Sewer System with pumping station and forcemain	Costs shown are from the report's recommended service alternative. Current flows based upon existing dwellings. Ultimate flows based on build-out.
12	ST BEES DRIVE	Acreage from report = 10Ac. Petition Area boundary shown in County's GIS system mathces that shown in the report.	Petition inactive, has sewer costs for running thru Chartwell	Costs shown are from the report's recommended service alternative. Current flows based upon existing dwellings. Ultimate flows based on build-out.
13	NORTH PATUXENT RD	Acreage from report = 30Ac. Petition Area boundary shown in County's GIS system mathces that shown in the report.	Schematic Design with detailed cost estimate, grinder pumps with low pressure sewer	Costs shown are from the report's recommended service alternative. Current flows based upon existing dwellings. Ultimate flows based on build-out.
14	DAVID VICTORIA LA	Acreage from report = 15.22Ac. Petition Area boundary shown in County's GIS system mathces that shown in the report.	Schematic Design with detailed cost estimate, water distribution system & Gravity Sewer	Costs shown are from the report's recommended service alternatives. No annual costs or O&M done for water petition. Current flows based upon existing dwellings. Ultimate flows based on build-out.
15	SABRINA PARK SANITARY SEWER	Acreage from report = 45Ac. Petition Area boundary shown in County's GIS system mathces that shown in the report.	Schematic Design with detailed cost estimate recommended complete gravity system. Design drawings show gravity sewer system & grinder pumps with Low Pressure Sewer.	Costs shown are from the report numbers using the recommended alternative selected, however the current design documents do not reflect this alternative. No costs are provided with design docs. Current flows based upon existing dwellings. Ultimate flows based on build-out.

Attachment B - Sewer Extension Design Schematics



Sewer Extension and Cluster Treatment Schematic - Riverdale

Legend

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- SepticProbArea
- PetitionAreas_03052007
- OSDS_Study_Area_Final
- bogs_cda
- WSSC
- Wetlands

Sewer Planning Categories

SEWER_TYPE
- Capital Facilities
- Existing Service
- Future Service
- No Public Service
- Other
- Park
- Planned Service
- Resource Conservation Area
- Water

Riverdale Prop. Sewer Extensions

Layer
- Prop. Gravity
- Prop. Pressure Sewer
- CTF

OSDS_priority_ranks
s_SWCCASlope
- 1.0 - 1.50
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0

Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan

CH2MHILL

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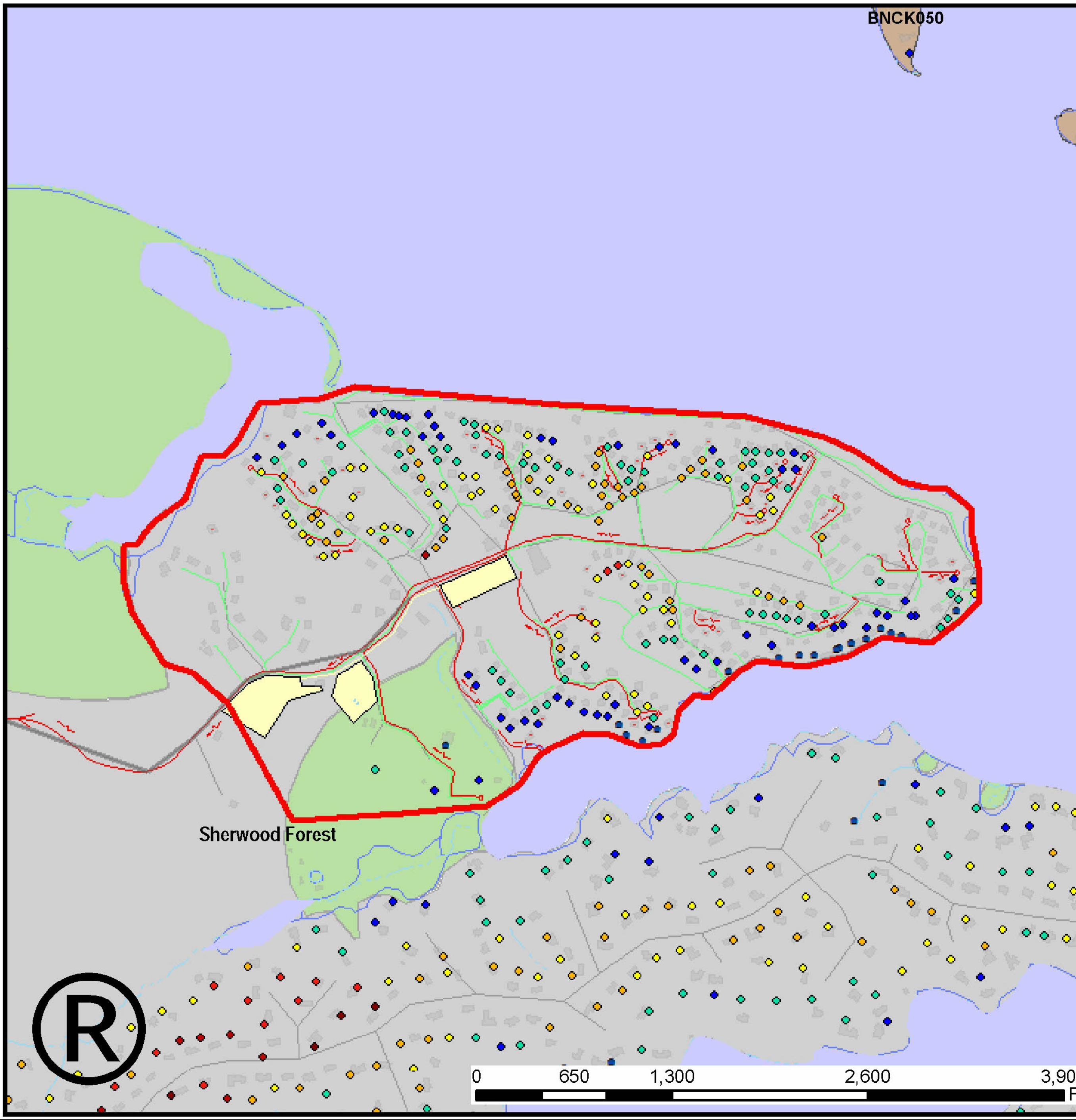


Sewer Extension and Cluster Treatment Schematic - Sherwood Forest

Legend

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- SepticProbArea
- PetitionAreas_03052007
- OSDS_Study_Area_Final
- bogs_cda
- WSSC
- Wetlands

Sewer Planning Categories
SEWER_TYPE
- Capital Facilities
- Existing Service
- Future Service
- No Public Service
- Other
- Park
- Planned Service
- Resource Conservation Area
- Water

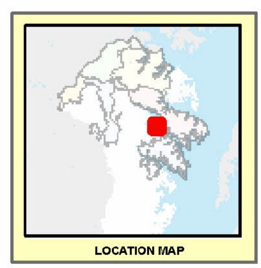
Sherwood Forest Prop. Sewer Extension

Layer
- Prop. Gravity
- Prop. Pressure Sewer

Layer
- CTF

Layer
- C-PIPE

OSDS_priority_ranks
s_SWCCASlope
- 1.0 - 1.50
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0



Anne Arundel County
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CH2MHILL

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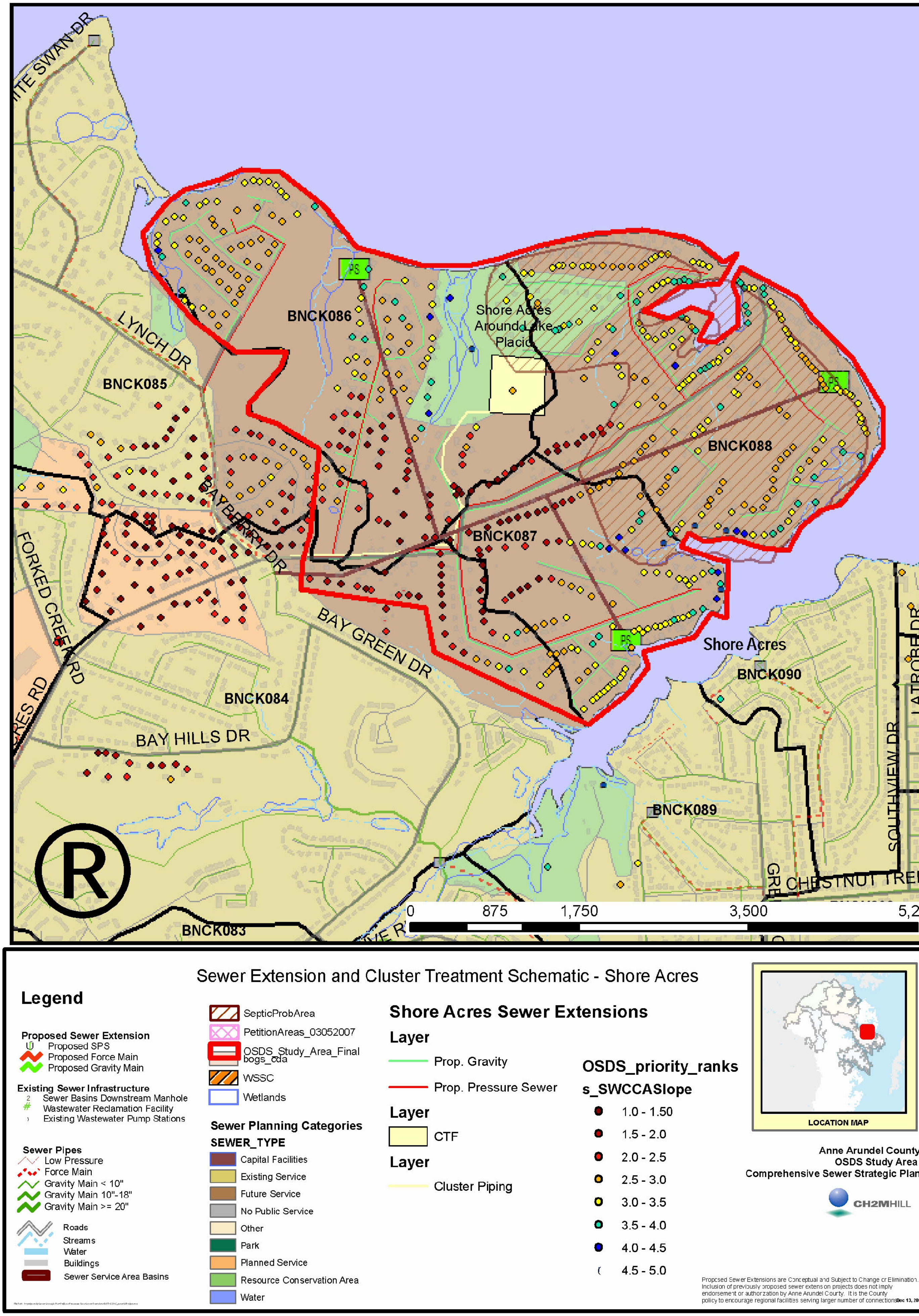

Sewer Extension and Cluster Treatment Schematic - Shore Acres
BNCK086
BNCK085
BNCK084
BNCK083
BNCK087
BNCK088
BNCK089
BNCK090
Shore Acres Around Lake Placid
Shore Acres
LYNCH DR
BAYBERRY DR
FORKED CREEK RD
BAY GREEN DR
BAY HILLS DR
CHESTNUT TREE
SOUTHVIEW DR
LATROBE DR
PS
0
875
1,750
3,500
5,250
Feet
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
bogs_cda
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Shore Acres Sewer Extensions
Layer
Prop. Gravity
Prop. Pressure Sewer
Layer
CTF
Layer
Cluster Piping
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
LOCATION MAP
Anne Arundel County
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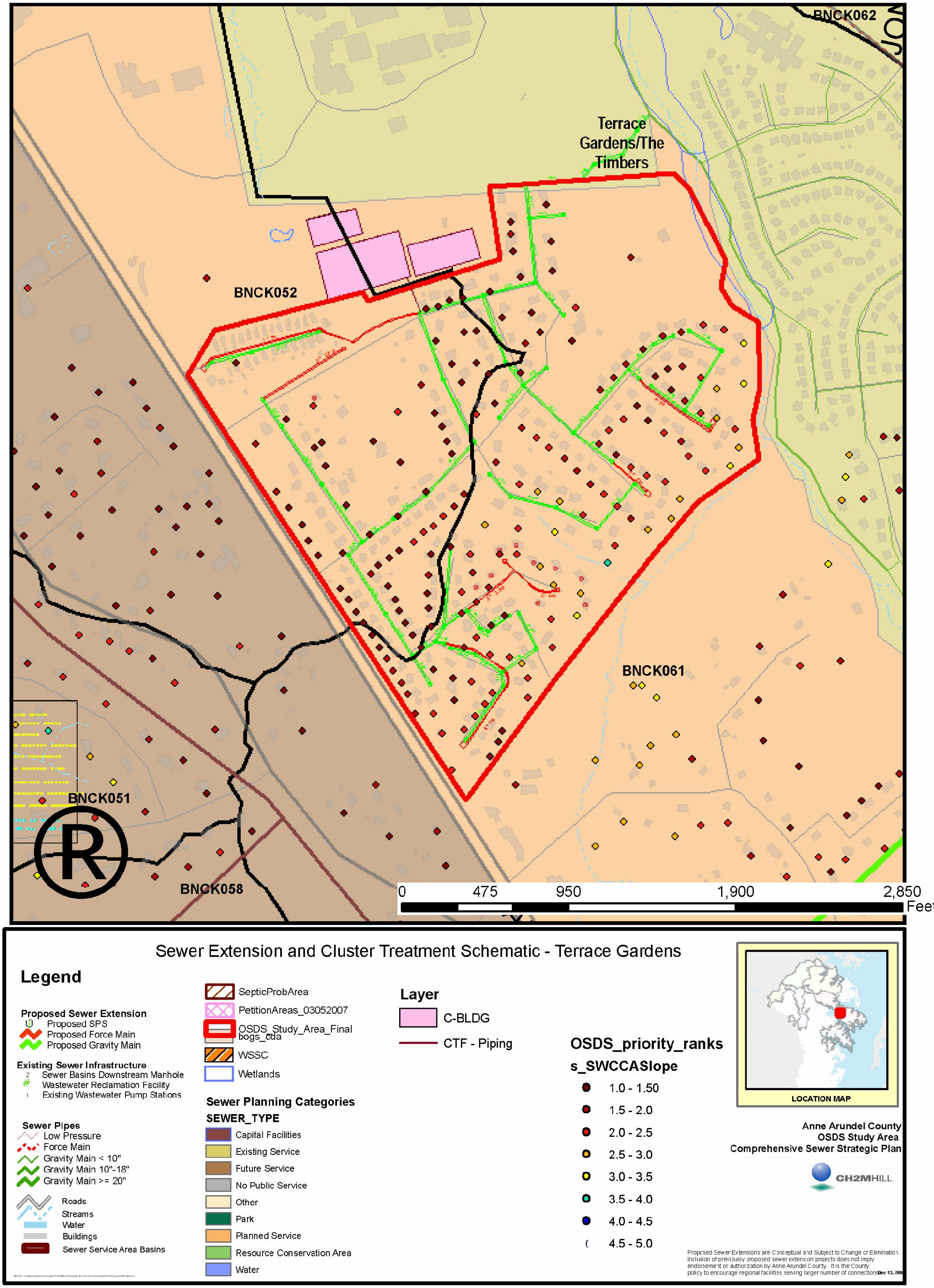

BNCK062
Terrace Gardens/The Timbers
BNCK052
BNCK061
BNCK051
BNCK058
0
475
950
1,900
2,850
Feet
Sewer Extension and Cluster Treatment Schematic - Terrace Gardens
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
bogs_cda
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Layer
C-BLDG
CTF - Piping
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
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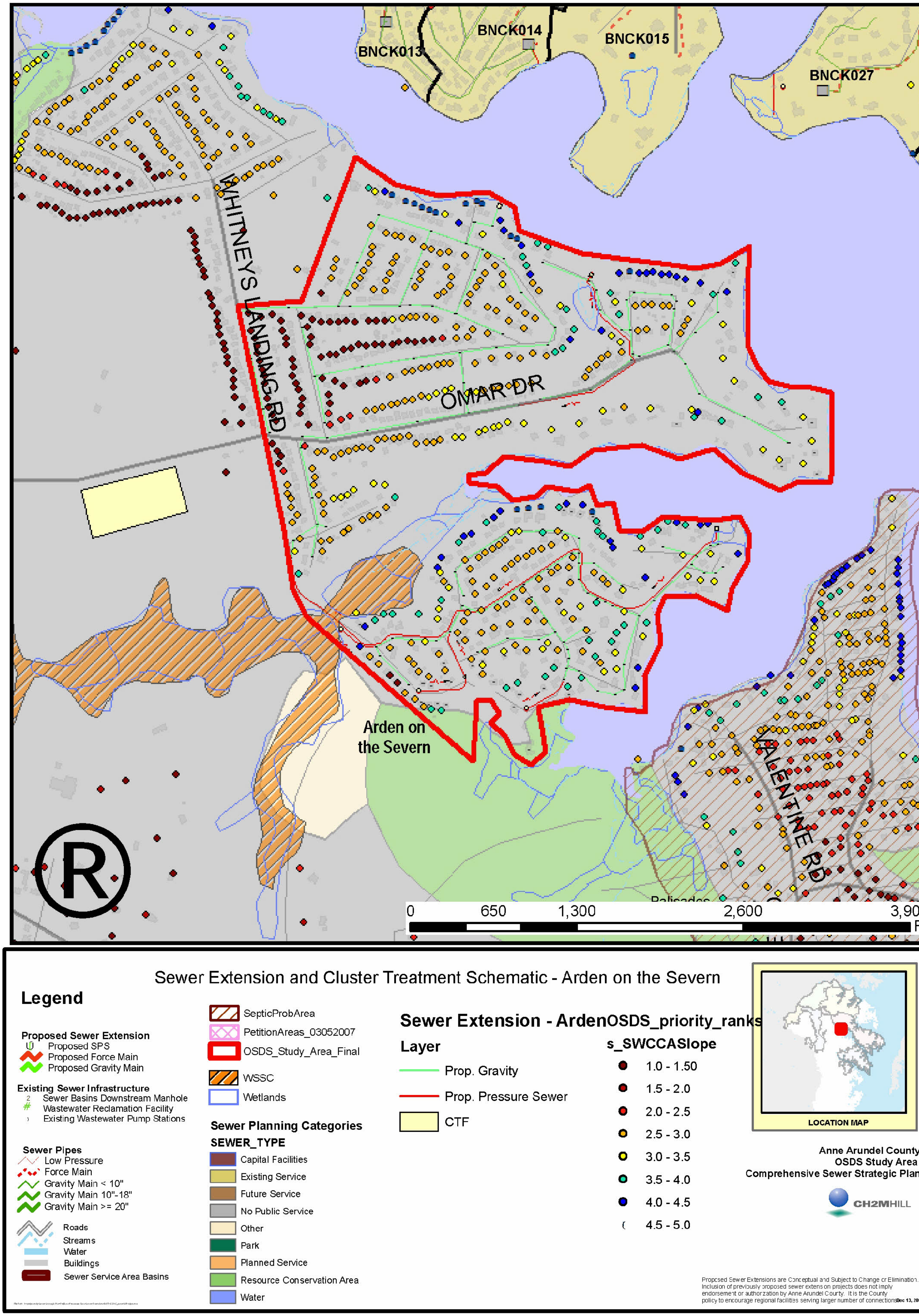

BNCK013
BNCK014
BNCK015
BNCK027
WHITNEYS LANDING RD
OMAR DR
Arden on the Severn
VALENTINE RD
0
650
1,300
2,600
3,900
Feet
Sewer Extension and Cluster Treatment Schematic - Arden on the Severn
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Sewer Extension - ArdenOSDS_priority_ranks
Layer
Prop. Gravity
Prop. Pressure Sewer
CTF
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
LOCATION MAP
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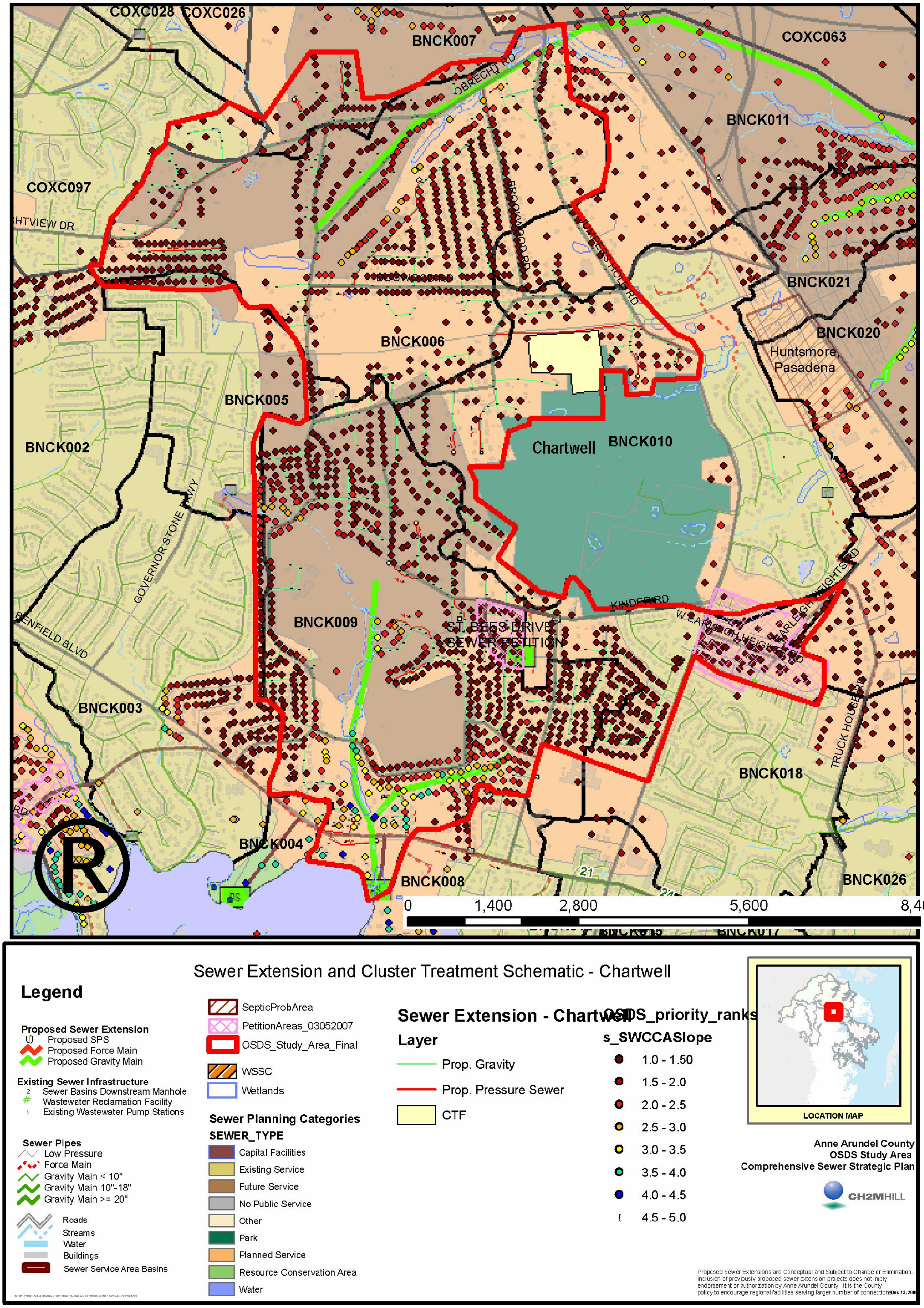

COXC028
COXC026
BNCK007
COXC063
OBRECHT RD
BNCK011
COXC097
BRIGHTVIEW DR
BROOKWOOD RD
DOGWOOD RD
BNCK021
BNCK020
BNCK006
Huntsmore,
Pasadena
BNCK005
BNCK002
Chartwell
BNCK010
GOVERNOR STONE PKWY
KINDER RD
BENFIELD BLVD
BNCK009
ST. BEES DRIVE
SEWER PETITION
BNCK003
TRUCK HOUSE RD
BNCK018
BNCK004
BNCK008
BNCK026
0
1,400
2,800
5,600
8,400
Feet
Sewer Extension and Cluster Treatment Schematic - Chartwell
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Sewer Extension - Chartwell
Layer
Prop. Gravity
Prop. Pressure Sewer
CTF
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
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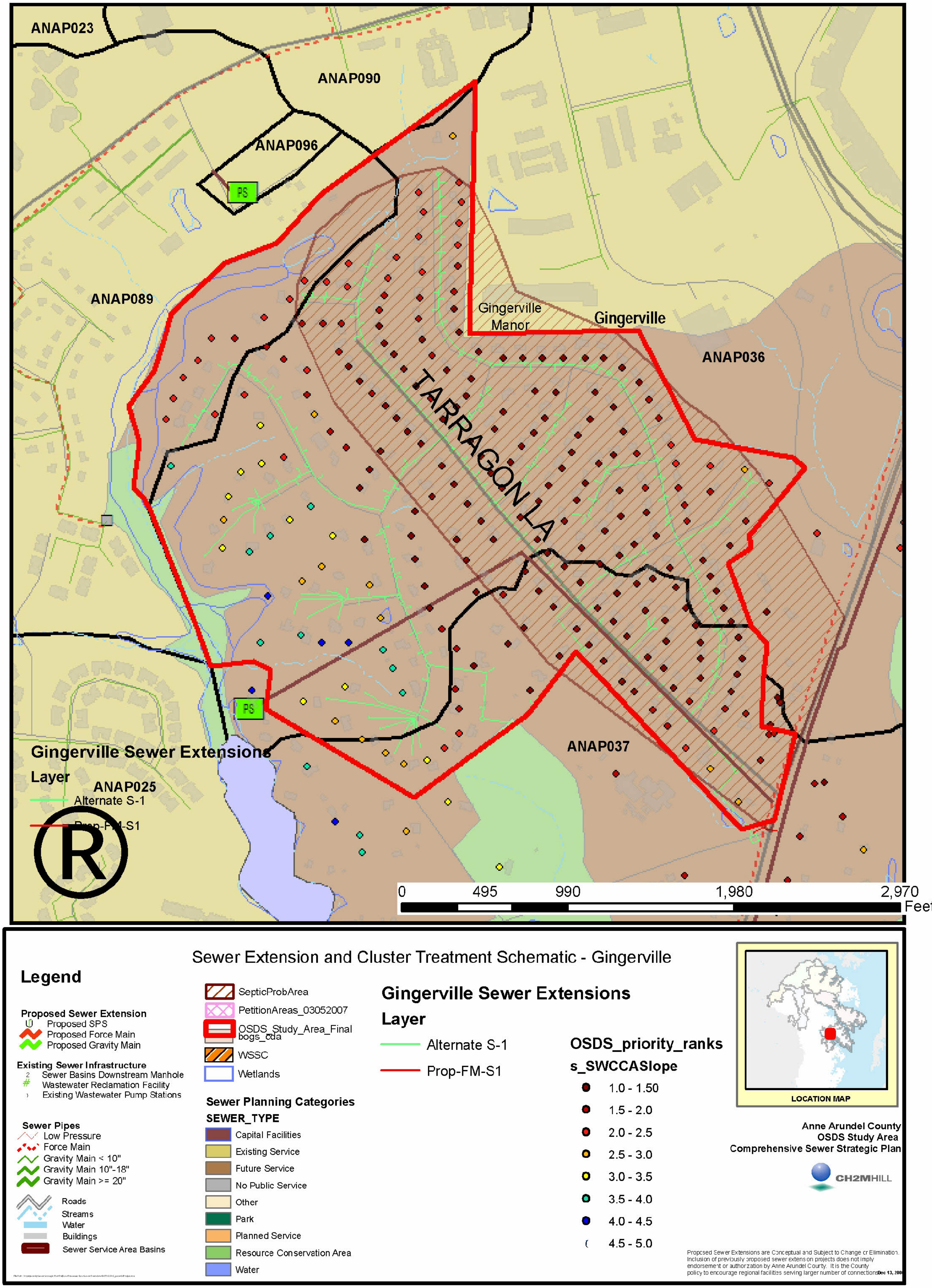
ANAP023
ANAP090
ANAP096
PS
ANAP089
Gingerville Manor
Gingerville
ANAP036
TARRAGON LA
ANAP037
ANAP025
PS
Gingerville Sewer Extensions
Layer
Alternate S-1
Prop-FM-S1
0
495
990
1,980
2,970
Feet
Sewer Extension and Cluster Treatment Schematic - Gingerville
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
bogs_cda
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Gingerville Sewer Extensions
Layer
Alternate S-1
Prop-FM-S1
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
LOCATION MAP
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Comprehensive Sewer Strategic Plan
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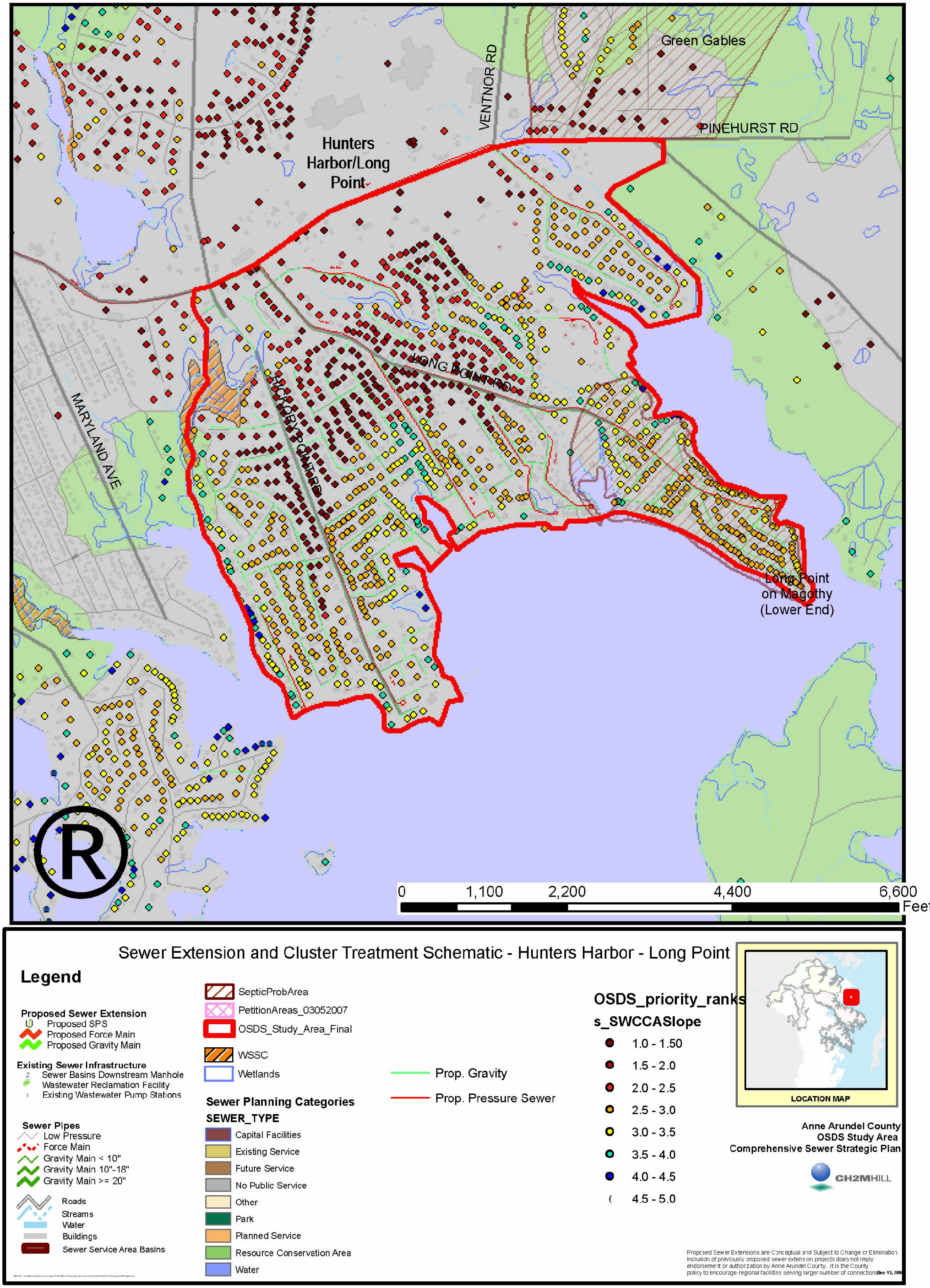
Green Gables
VENTNOR RD
PINEHURST RD
Hunters Harbor/Long Point
LONG POINT RD
HICKORY POINT RD
MARYLAND AVE
Long Point on Magothy (Lower End)
0
1,100
2,200
4,400
6,600
Feet
Sewer Extension and Cluster Treatment Schematic - Hunters Harbor - Long Point
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Prop. Gravity
Prop. Pressure Sewer
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
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Comprehensive Sewer Strategic Plan
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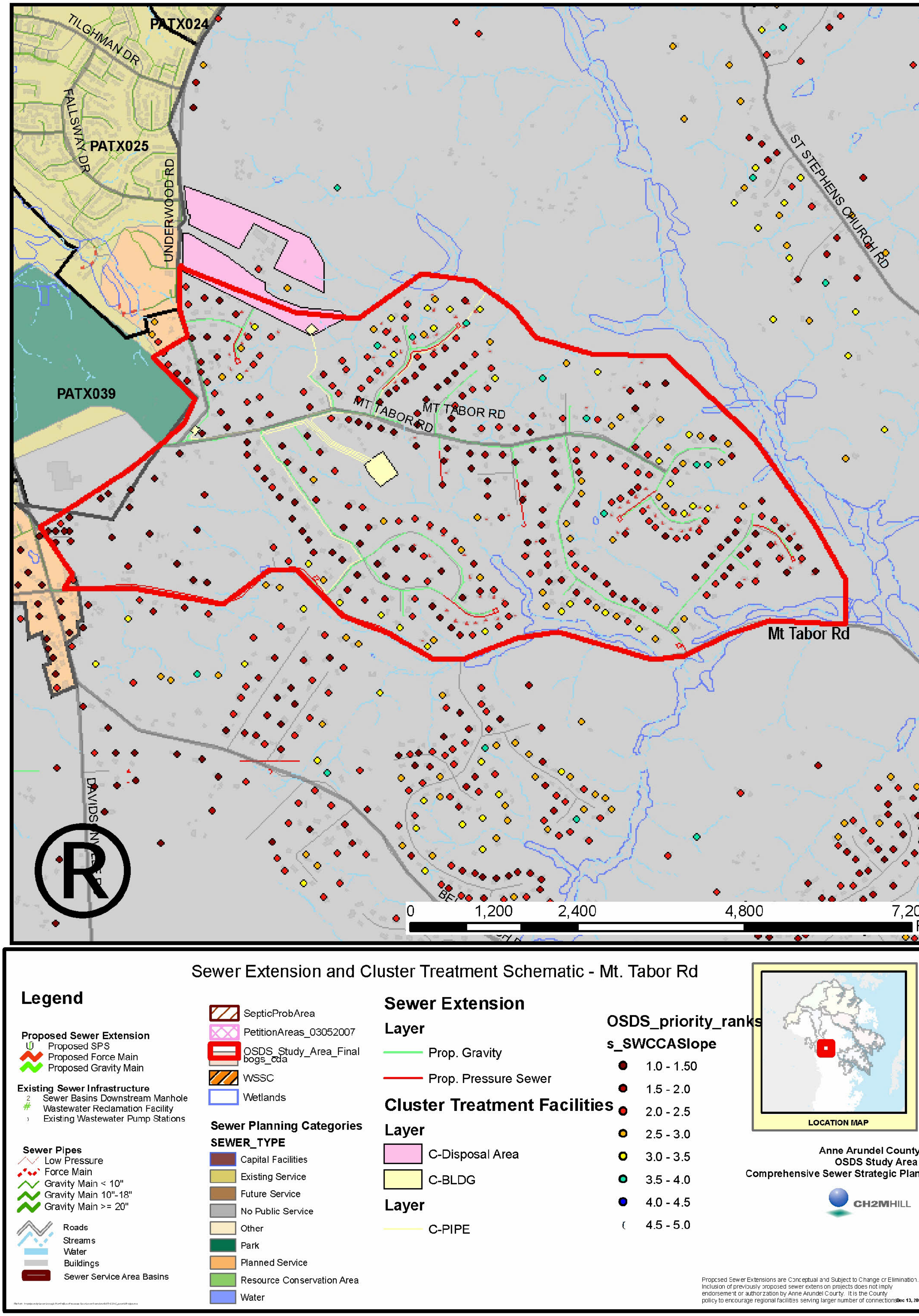

PATX024
TILGHMAN DR
FALLSWAY DR
PATX025
UNDERWOOD RD
PATX039
ST STEPHENS CHURCH RD
MT TABOR RD
MT TABOR RD
Mt Tabor Rd
0
1,200
2,400
4,800
7,200
Feet
Sewer Extension and Cluster Treatment Schematic - Mt. Tabor Rd
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
bogs_cda
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Sewer Extension
Layer
Prop. Gravity
Prop. Pressure Sewer
Cluster Treatment Facilities
Layer
C-Disposal Area
C-BLDG
Layer
C-PIPE
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
LOCATION MAP
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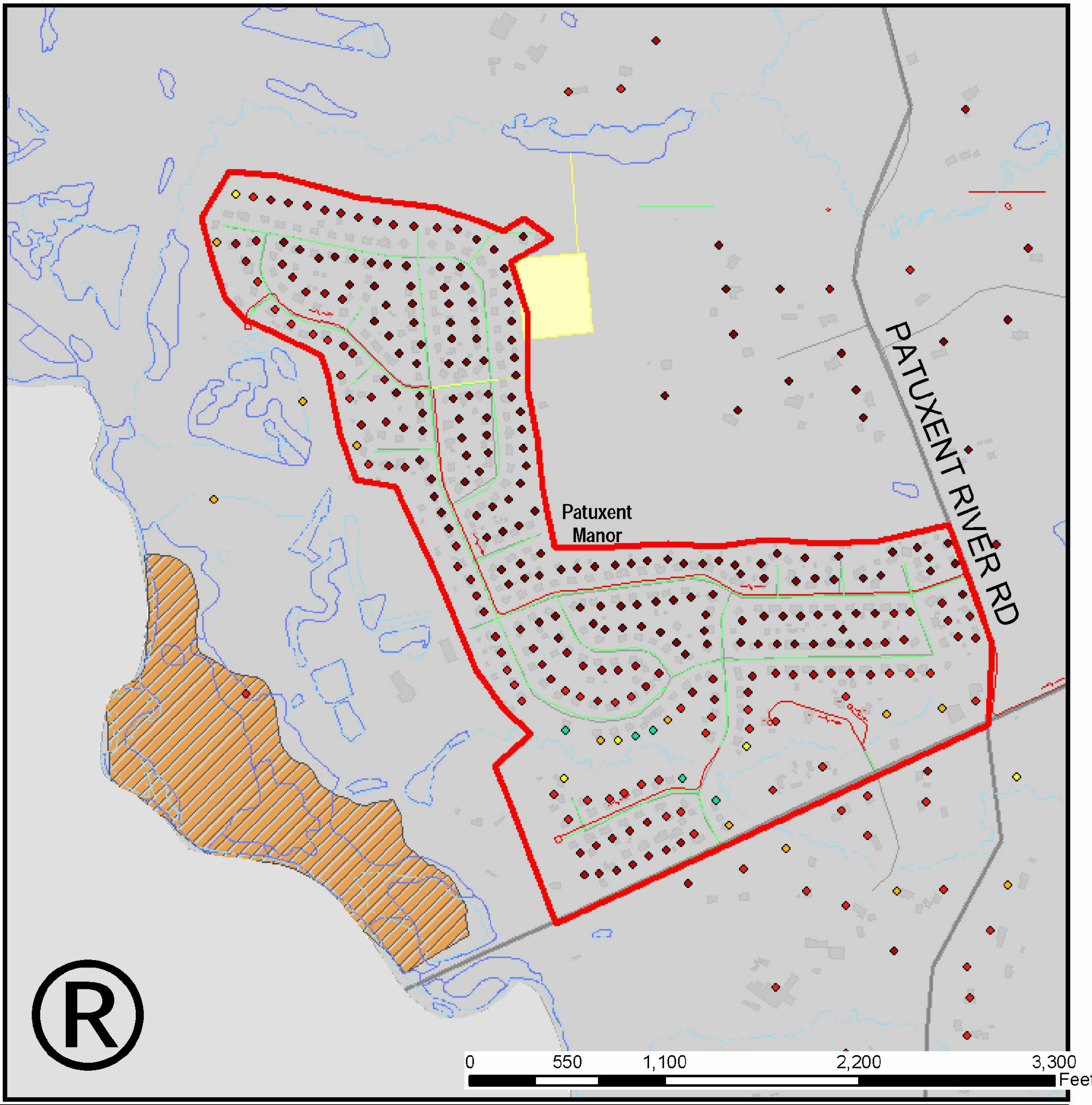
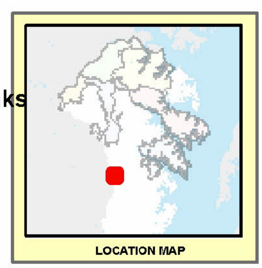
AR0022195



Sewer Extension and Cluster Treatment Schematic - Patuxent Manor



Legend

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- SepticProbArea
- PetitionAreas_03052007
- OSDS_Study_Area_Final
- WSSC
- Wetlands

Sewer Planning Categories
SEWER_TYPE
- Capital Facilities
- Existing Service
- Future Service
- No Public Service
- Other
- Park
- Planned Service
- Resource Conservation Area
- Water

- Prop. Gravity
- Prop. Pressure Sewer
- CTF
- CTF Piping

OSDS_priority_ranks
s_SWCCASlope
- 1.0 - 1.50
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0

Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan

CH2MHILL

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Attachment C – Sewer Extension Cost Estimates

											Quantity (l.f.)
Study Area Name	**Type**	**ID #**	**Original Acres**	**Original # of OSDS**	**Density (# of OSDS/acre)**	**Ave. Distance to Sewer (feet)**	**Acres / System**	**SSA**	**SubSSA**	**Total ConstructionCost**	8" Gravity Sewer (includes MH)
Riverdale	S	5	405	705	1.74	2173	0.57	BNCK	24,25	**$35,843,150**	62980
Arden - Pump across creek	S	7	305	471	1.54	2754	0.65	NPS/RCA		**$16,226,085**	27590
Arden - Pump across country	S	7	305	471	1.54	2754	0.65	NPS/RCA		**$21,902,698**	27590
Severn Run/Pointfield Landing	S	9	122	175	1.43	545	0.70	BNCK	2,3	**$0**	
Terrace Gardens - Max Grinders	S	11	146	181	1.24	1646	0.80	BNCK	52,61	**$7,231,515**	9915
Terrace Gardens - Min Grinders	S	11	146	181	1.24	1646	0.80	BNCK	52,61	**$7,633,425**	13515
Sherwood Forest	S	12	331	349	1.05	8767	0.95	NPS/RCA		**$29,250,138**	36585
Gingerville	S	13	236	244	1.04	1027	0.97	ANAP	36,37,89	**$9,792,888**	13650
Hunters Harbor/Long Point	S	15	1164	1120	0.96	8723	1.04	NPS/RCA		**$53,746,463**	85695
Chartwell	S	16	1774	1618	0.91	1379	1.10	BNCK,COXC	BNCK-2,3,4,5,6,7,8,10,11,18; COXC-26,28,	**$75,882,880**	136350
Shore Acres	S	17	496	449	0.90	1932	1.11	BNCK	84,85,86,87,88	**$23,341,018**	34445
Mt. Tabor Rd - Patuxant	S	22	1039	343	0.33	7445	3.03	NPS		**$19,353,288**	36450
Patuxent Manor	S		163	282	1.73	70000	0.58	NPS		**$21,876,250**	21625

*** An additional submersible PS is included**

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AR0022198

	Cost (l.f.)	**Total Cost**	Quantity (ea)	Cost (ea)	**Total Cost**	Quantity (ea)	Cost (ea)	**Total Cost**	Quantity (ea)
Study Area Name	8" Gravity Sewer (includes MH)	**8" Gravity Sewer (includes MH)**	4" SHC (includes C.O. and 80 l.f. pipe)	4" SHC (includes C.O. and 80 l.f. pipe)	**4" SHC (includes C.O. and 80 l.f. pipe)**	Abandon Existing Septic Tank	Abandon Existing Septic Tank	**Abandon Existing Septic Tank**	Simplex Grinder Pump (includes elecrical work)
Riverdale	$200	$12,596,000	890	$3,000	$2,670,000	909	$2,000	$1,818,000	19
Arden - Pump across creek	$200	$5,518,000	436	$3,000	$1,308,000	468	$2,000	$936,000	32
Arden - Pump across country	$200	$5,518,000	436	$3,000	$1,308,000	468	$2,000	$936,000	32
Severn Run/Pointfield Landing	$200	$0		$3,000	$0	0	$2,000	$0	
Terrace Gardens - Max Grinders	$200	$1,983,000	120	$3,000	$360,000	207	$2,000	$414,000	87
Terrace Gardens - Min Grinders	$200	$2,703,000	197	$3,000	$591,000	207	$2,000	$414,000	10
Sherwood Forest	$200	$7,317,000	311	$3,000	$933,000	349	$2,000	$698,000	38
Gingerville	$200	$2,730,000	159	$3,000	$477,000	232	$2,000	$464,000	73
Hunters Harbor/Long Point	$200	$17,139,000	1077	$3,000	$3,231,000	1094	$2,000	$2,188,000	17
Chartwell	$200	$27,270,000	1325	$3,000	$3,975,000	1347	$2,000	$2,694,000	22
Shore Acres	$200	$6,889,000	512	$3,000	$1,536,000	516	$2,000	$1,032,000	4
Mt. Tabor Rd - Patuxant	$200	$7,290,000	298	$3,000	$894,000	328	$2,000	$656,000	30
Patuxent Manor	$200	$4,325,000	306	$3,000	$918,000	310	$2,000	$620,000	4

*** An additional submersible PS is in**

	Cost (ea)	**Total Cost**	Quantity (l.f.)	Cost (l.f.)	**Total Cost**	Quantity (l.f.)	Cost (l.f.)
Study Area Name	Simplex Grinder Pump (includes elecrical work)	**Simplex Grinder Pump (includes elecrical work)**	1-1/2" Low Pressure Sewer (includes valves, etc.)	1-1/2" Low Pressure Sewer (includes valves, etc.)	**1-1/2" Low Pressure Sewer (includes valves, etc.)**	2" Low Pressure Sewer (includes valves, etc.)	2" Low Pressure Sewer (includes valves, etc.)
Riverdale	$15,000	$285.000		$24	$0	695	$30
Arden - Pump across creek	$15,000	$480.000	315	$24	$7,560	815	$30
Arden - Pump across country	$15,000	$480.000	315	$24	$7,560	815	$30
Severn Run/Pointfield Landing	$15,000	$0		$24	$0		$30
Terrace Gardens - Max Grinders	$15,000	$1,305.000		$24	$0	4080	$30
Terrace Gardens - Min Grinders	$15,000	$150.000		$24	$0	1260	$30
Sherwood Forest	$15,000	$570.000		$24	$0	2230	$30
Gingerville	$15,000	$1,095.000	3740	$24	$89,760	1745	$30
Hunters Harbor/Long Point	$15,000	$255.000		$24	$0	920	$30
Chartwell	$15,000	$330.000	455	$24	$10,920	2650	$30
Shore Acres	$15,000	$60.000		$24	$0		$30
Mt. Tabor Rd - Patuxant	$15,000	$450.000		$24	$0	1180	$30
Patuxent Manor	$15,000	$60.000		$24	$0	1025	$30

*** An additional submersible PS is in**

	Total Cost	Quantity (l.f.)	Cost (l.f.)	**Total Cost**	Quantity (l.f.)	Cost (l.f.)	**Total Cost**
Study Area Name	**2" Low Pressure Sewer (includes valves, etc.)**	3" Low Pressure Sewer (includes valves, etc.)	3" Low Pressure Sewer (includes valves, etc.)	**3" Low Pressure Sewer (includes valves, etc.)**	4" Low Pressure Sewer (includes valves, etc.)	4" Low Pressure Sewer (includes valves, etc.)	**4" Low Pressure Sewer (includes valves, etc.)**
Riverdale	$20,850		$36	$0		$42	$0
Arden - Pump across creek	$24,450	380	$36	$13,680		$42	$0
Arden - Pump across country	$24,450	380	$36	$13,680		$42	$0
Severn Run/Pointfield Landing	$0		$36	$0		$42	$0
Terrace Gardens - Max Grinders	$122,400	1710	$36	$61,560		$42	$0
Terrace Gardens - Min Grinders	$37,800		$36	$0		$42	$0
Sherwood Forest	$66,900		$36	$0		$42	$0
Gingerville	$52,350	2165	$36	$77,940	0	$42	$0
Hunters Harbor/Long Point	$27,600		$36	$0		$42	$0
Chartwell	$79,500		$36	$0		$42	$0
Shore Acres	$0		$36	$0		$42	$0
Mt. Tabor Rd - Patuxant	$35,400		$36	$0		$42	$0
Patuxent Manor	$30,750		$36	$0		$42	$0

*** An additional submersible PS is in**

	Quantity (l.f.)	Cost (l.f.)	**Total Cost**		Quantity (l.f.)	Cost (l.f.)	**Total Cost**	Quantity (ea.)
Study Area Name	Trench Paving and Overlay	Trench Paving and Overlay	**Trench Paving and Overlay**	**Accessories, Mob, Sed Con, Traffic Con Etc**	Easements (Includes 20' perm. And 10' temp.)	Easements (Includes 20' perm. And 10' temp.)	**Easements (Includes 20' perm. And 10' temp.)**	Small Submersible in MH (150 K)
Riverdale	76850	$45	$3,458,250	$9,741,050		$100	$0	3
Arden - Pump across creek	29955	$45	$1,347,975	$4,441,195	445	$100	$44,500	2
Arden - Pump across country	29955	$45	$1,347,975	$5,916,733	445	$100	$44,500	2
Severn Run/Pointfield Landing		$45	$0	$0		$100	$0	
Terrace Gardens - Max Grinders	13890	$45	$625,050	$2,255,505	1050	$100	$105,000	
Terrace Gardens - Min Grinders	13890	$45	$625,050	$2,084,975	1875	$100	$187,500	4
Sherwood Forest	51725	$45	$2,327,625	$7,385,713	600	$100	$60,000	9
Gingerville	16125	$45	$725,625	$2,627,963	1820	$100	$182,000	
Hunters Harbor/Long Point	85690	$45	$3,856,050	$14,588,488		$100	$0	5
Chartwell	145225	$45	$6,535,125	$19,535,960		$100	$0	7
Shore Acres	36466	$45	$1,640,970	$5,501,673		$100	$0	2
Mt. Tabor Rd - Patuxant	48325	$45	$2,174,625	$5,787,763	460	$100	$46,000	7
Patuxent Manor	22650	$45	$1,019,250	$5,402,750		$100	$0	

*** An additional submersible PS is in**

			Cost Data						
	Total Cost	Quantity (ea.)	Pumping Station Information				Quantity (l.f.)	Cost (l.f.)	**Total Cost**
Study Area Name	**Small Submersible in MH (150 K)**	Std. AA Co. Submersible (1 - 1.25 mil)	**Submersible (up to 400 gpm)**	**Precast Wet Well/Dry Well (401-2083 gpm)**	**Poured in Place (over 2083 gpm)**	**Shellfish Storage?**	4" Force Main (includes valves, etc.)	4" Force Main (includes valves, etc.)	**4" Force Main (includes valves, etc.)**
Riverdale	$450,000			$3,500,000				$70	$0
Arden - Pump across creek	$300,000	1	$1,250,000			Yes	6340	$70	$443,800
Arden - Pump across country	$300,000	2	$2,500,000			Yes	6340	$70	$443,800
Severn Run/Pointfield Landing	$0							$70	$0
Terrace Gardens - Max Grinders	$0							$70	$0
Terrace Gardens - Min Grinders	$600,000					No	3430	$70	$240,100
Sherwood Forest	$1,350,000	1	$1,250,000	$3,500,000		Yes	9060	$70	$634,200
Gingerville	$0	1	$1,250,000			Yes		$70	$0
Hunters Harbor/Long Point	$750,000	2	$2,500,000	$3,500,000		Yes	8495	$70	$594,650
Chartwell	$1,050,000	7	$8,750,000	$3,500,000		Yes	16080	$70	$1,125,600
Shore Acres	$300,000	4	$5,000,000			Yes	11070	$70	$774,900
Mt. Tabor Rd - Patuxant	$1,050,000					No	13850	$70	$969,500
Patuxent Manor	$0	1	$1,250,000	$3,500,000		Yes	1100	$70	$77,000

*** An additional submersible PS is in**

UNIT COSTS FOR SEWER EXTENSION COMPONENTS

Pipe Size/Type	Material	Base Price per foot - includes MHs	Trench Paving per LF - 7' w 6.5" depth and full lane overlay	Multiply Total by 1.5 for Accessories, Mob, Sed Con, Traffic Con Etc
8-in Gravity Sewer	Not Specified	$ 200.00	$ 45.00	x 1.5
4-in Force Main	HDPE - Open Cut	$ 70.00	$ 45.00	x 1.5
6-in Force Main	HDPE - Open Cut	$ 85.00	$ 45.00	x 1.5
8-in Force Main	HDPE - Open Cut	$ 100.00	$ 45.00	x 1.5
10-in Force Main	HDPE - Open Cut	$ 105.00	$ 45.00	x 1.5
12-in Force Main	HDPE - Open Cut	$ 110.00	$ 45.00	x 1.5
8-in Force Main	HDPE - HDD	$ 140.00	$ 45.00	x 1.5
10-in Force Main	HDPE - HDD	$ 160.00	$ 45.00	x 1.5
12-in Force Main	HDPE - HDD	$ 200.00	$ 45.00	x 1.5
1.5-in Low Pressure Sewer	HDPE - Open Cut	$ 24.00	$ 45.00	x 1.5
2-in Low Pressure Sewer	HDPE - Open Cut	$ 30.00	$ 45.00	x 1.5
3-in Low Pressure Sewer	HDPE - Open Cut	$ 36.00	$ 45.00	x 1.5
4-in Low Pressure Sewer	HDPE - Open Cut	$ 42.00	$ 45.00	x 1.5
Simplex Grinder Pump	Complete w/ elec	$ 15,000.00		x 1.5
Abandon Septic Tank - Drill/Fill	Not Specified	$ 2,000.00		x 1.5
4-in Sewer House Conn (SHC)	includes 80' pipe	$ 3,000.00		

UNIT COSTS FOR SEWER EXTENSION COMPONENTS

Pipe Size/Type	Material	Base Price per foot - includes MHs	Trench Paving per LF - 7' w 6.5" depth and full lane overlay	Multiply Total by 1.5 for Accessories, Mob, Sed Con, Traffic Con Etc
8-in Gravity Sewer	Not Specified	$ 200.00	$ 45.00	x 1.5
4-in Force Main	HDPE - Open Cut	$ 70.00	$ 45.00	x 1.5

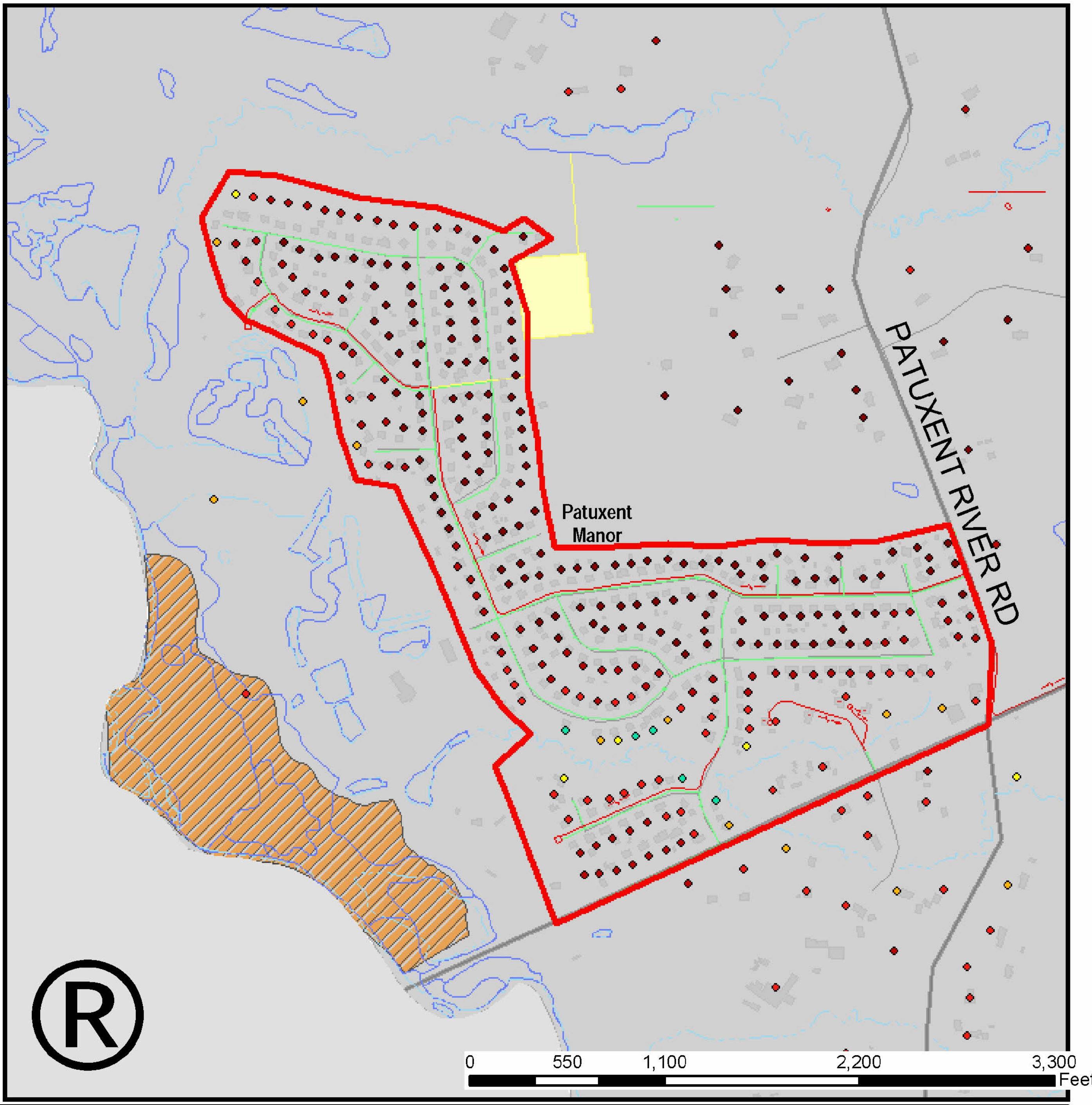
UNIT COSTS FOR SEWAGE PUMPING STATIONS

With Shellfish Storage Tank?	Submersible Station (up to 400 gpm)	Precast Wet Well/Dry Well (401-2083 gpm)	Poured in Place (over 2083 gpm)	Smith & Loveless MH installed submersible
No	$1.0 M	$3.0 M	$5.0 M	$150,000
Yes	$1.25 M	$3.5 M	$5.5 M	

EASEMENT COMPS

Assume 20' wide permanent utility easement @ $4 sf = $80 lf	80.00	
Assume 10' wide temporary const. strip @ $1.50 sf = $15 lf	15.00	
TOTAL EASEMENT COST PER LF	95.00	say $100 lf

Attachment D –Cluster Treatment Facility Design Schematics



Sewer Extension and Cluster Treatment Schematic - Patuxent Manor

Legend

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

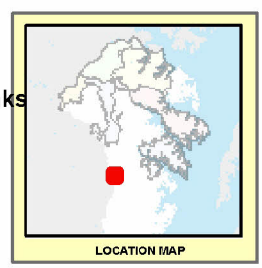
- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- SepticProbArea
- PetitionAreas_03052007
- OSDS_Study_Area_Final
- WSSC
- Wetlands

Sewer Planning Categories
SEWER_TYPE
- Capital Facilities
- Existing Service
- Future Service
- No Public Service
- Other
- Park
- Planned Service
- Resource Conservation Area
- Water

- Prop. Gravity
- Prop. Pressure Sewer
- CTF
- CTF Piping

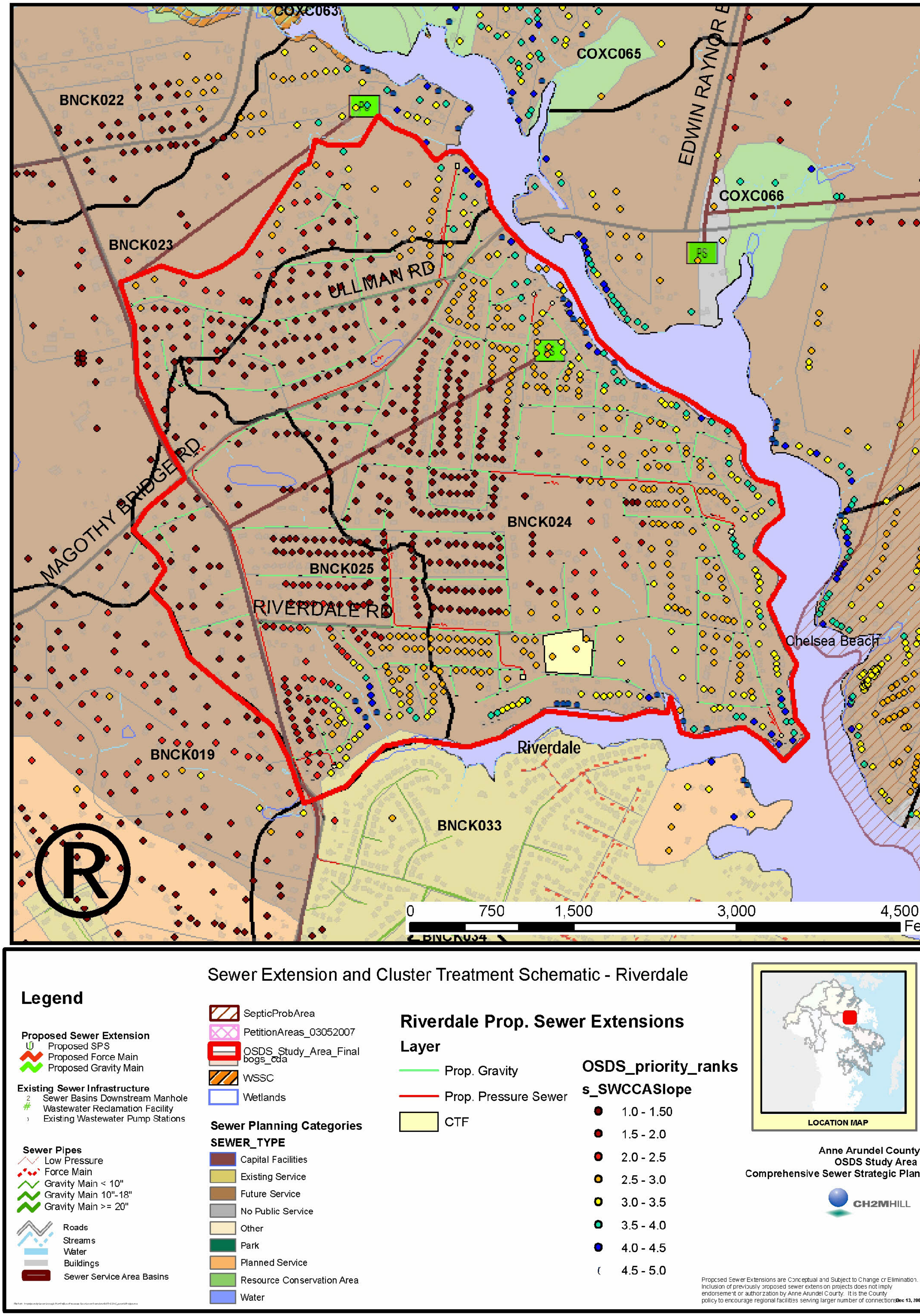
OSDS_priority_ranks
s_SWCCASlope
- 1.0 - 1.50
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0



Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan

CH2MHILL

Proposed Sewer Extensions are Conceptual and Subject to Change or Elimination. Inclusion of previously proposed sewer extension projects does not imply endorsement or authorization by Anne Arundel County. It is the County policy to encourage regional facilities serving larger number of connections. Dec 13, 2006



COXC063
COXC065
EDWIN RAYNOR B
COXC066
BNCK022
BNCK023
ULLMAN RD
MAGOTHY BRIDGE RD
BNCK024
BNCK025
RIVERDALE RD
Chelsea Beach
Riverdale
BNCK019
BNCK033
0
750
1,500
3,000
4,500
Feet
Sewer Extension and Cluster Treatment Schematic - Riverdale
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
bogs_cda
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Riverdale Prop. Sewer Extensions
Layer
Prop. Gravity
Prop. Pressure Sewer
CTF
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
LOCATION MAP
Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan
CH2MHILL
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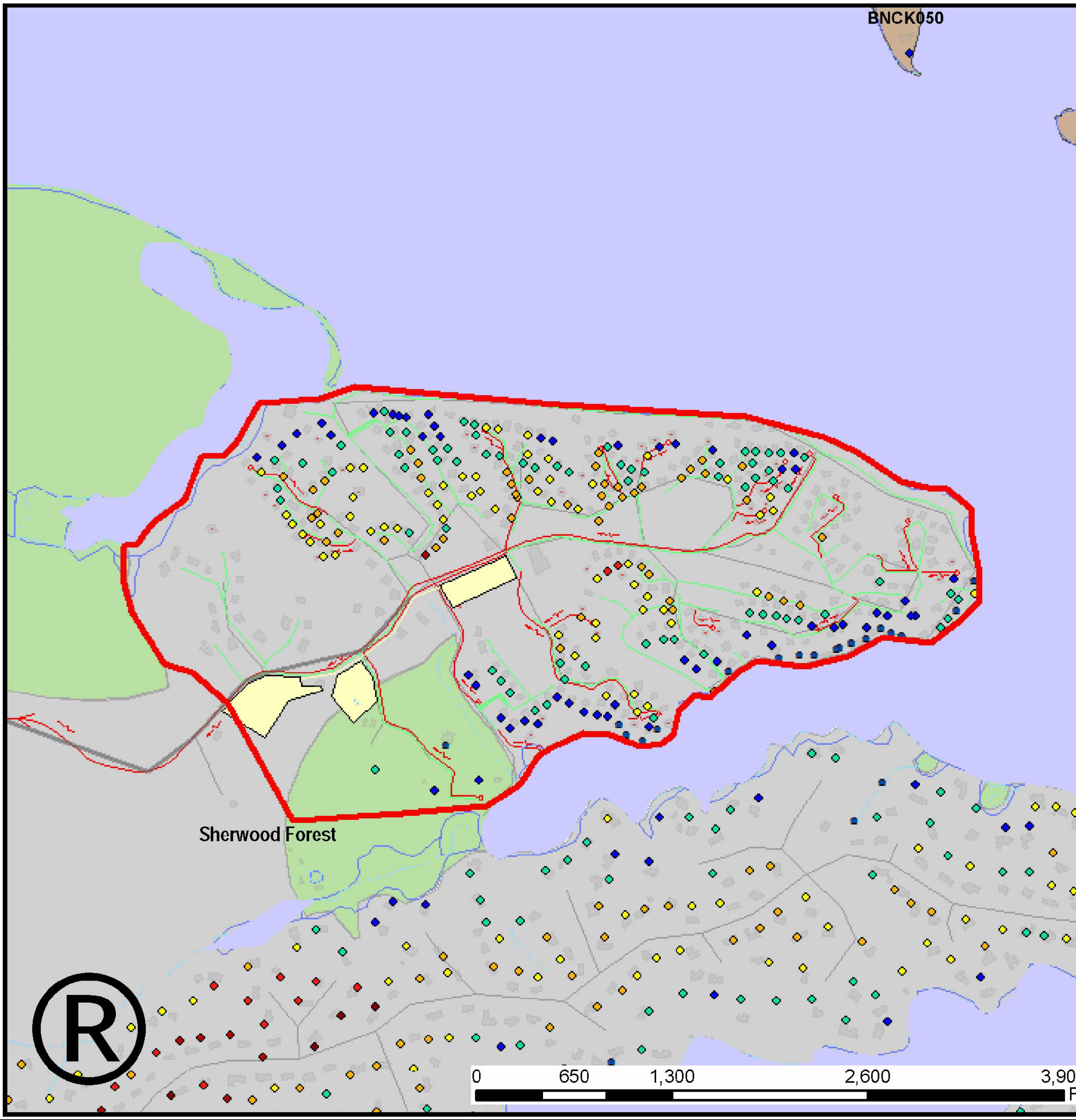
Dec 13, 200



Sewer Extension and Cluster Treatment Schematic - Sherwood Forest

Legend

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- SepticProbArea
- PetitionAreas_03052007
- OSDS_Study_Area_Final
- bogs_cda
- WSSC
- Wetlands

Sewer Planning Categories
SEWER_TYPE
- Capital Facilities
- Existing Service
- Future Service
- No Public Service
- Other
- Park
- Planned Service
- Resource Conservation Area
- Water

Sherwood Forest Prop. Sewer Extension

Layer
- Prop. Gravity
- Prop. Pressure Sewer

Layer
- CTF

Layer
- C-PIPE

OSDS_priority_ranks
s_SWCCASlope
- 1.0 - 1.50
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0

Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan

CH2MHILL

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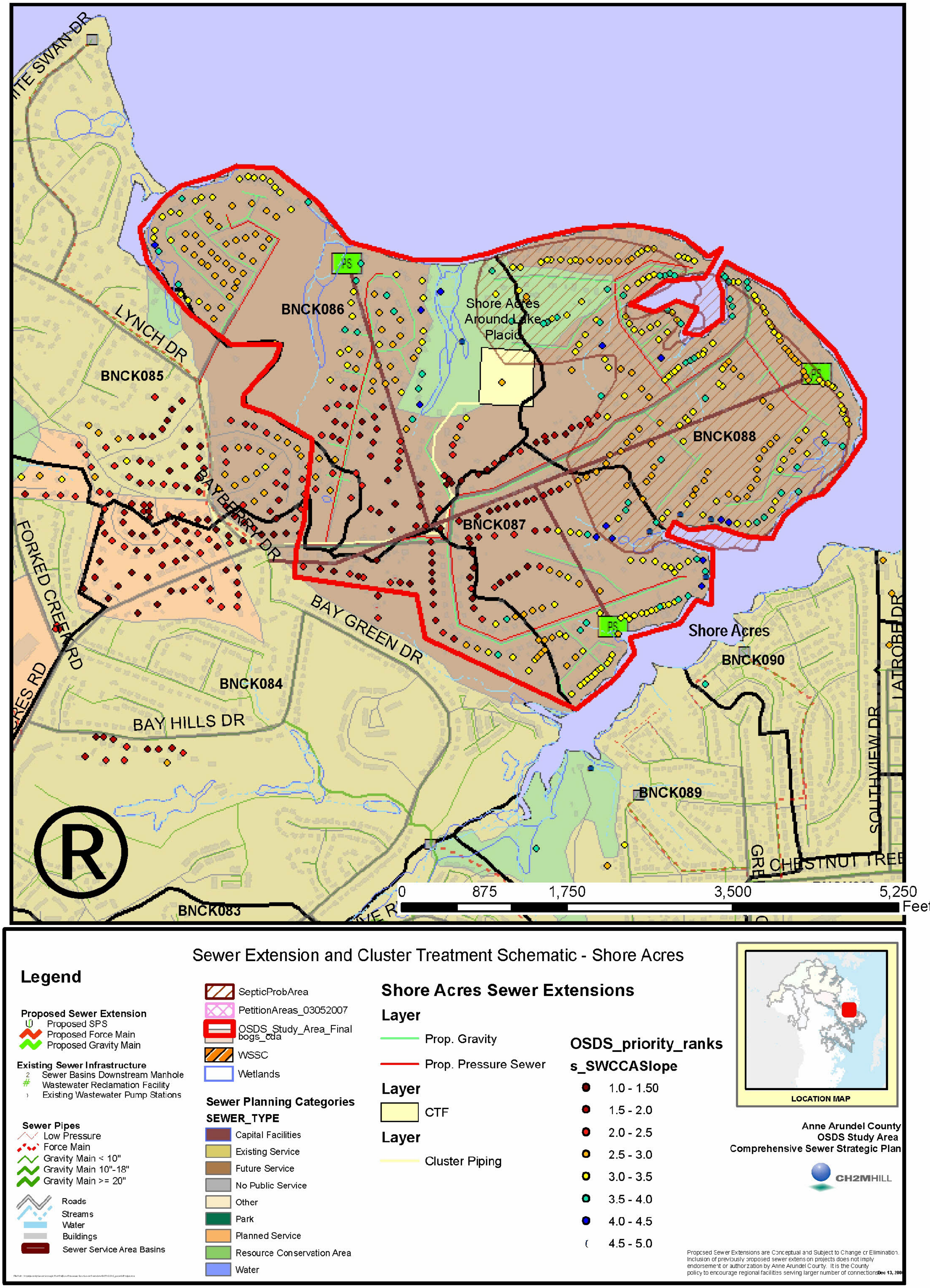

WHITE SWAN DR
LYNCH DR
BNCK085
BNCK086
Shore Acres Around Lake Placid
BNCK087
BNCK088
BAYBERRY DR
FORKED CREEK RD
BAY GREEN DR
BNCK084
BAY HILLS DR
Shore Acres
BNCK090
BNCK089
LATROBE DR
SOUTHVIEW DR
CHESTNUT TREE
BNCK083
0 875 1,750 3,500 5,250 Feet
Sewer Extension and Cluster Treatment Schematic - Shore Acres
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
bogs_cda
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Shore Acres Sewer Extensions
Layer
Prop. Gravity
Prop. Pressure Sewer
Layer
CTF
Layer
Cluster Piping
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
LOCATION MAP
Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan
CH2MHILL
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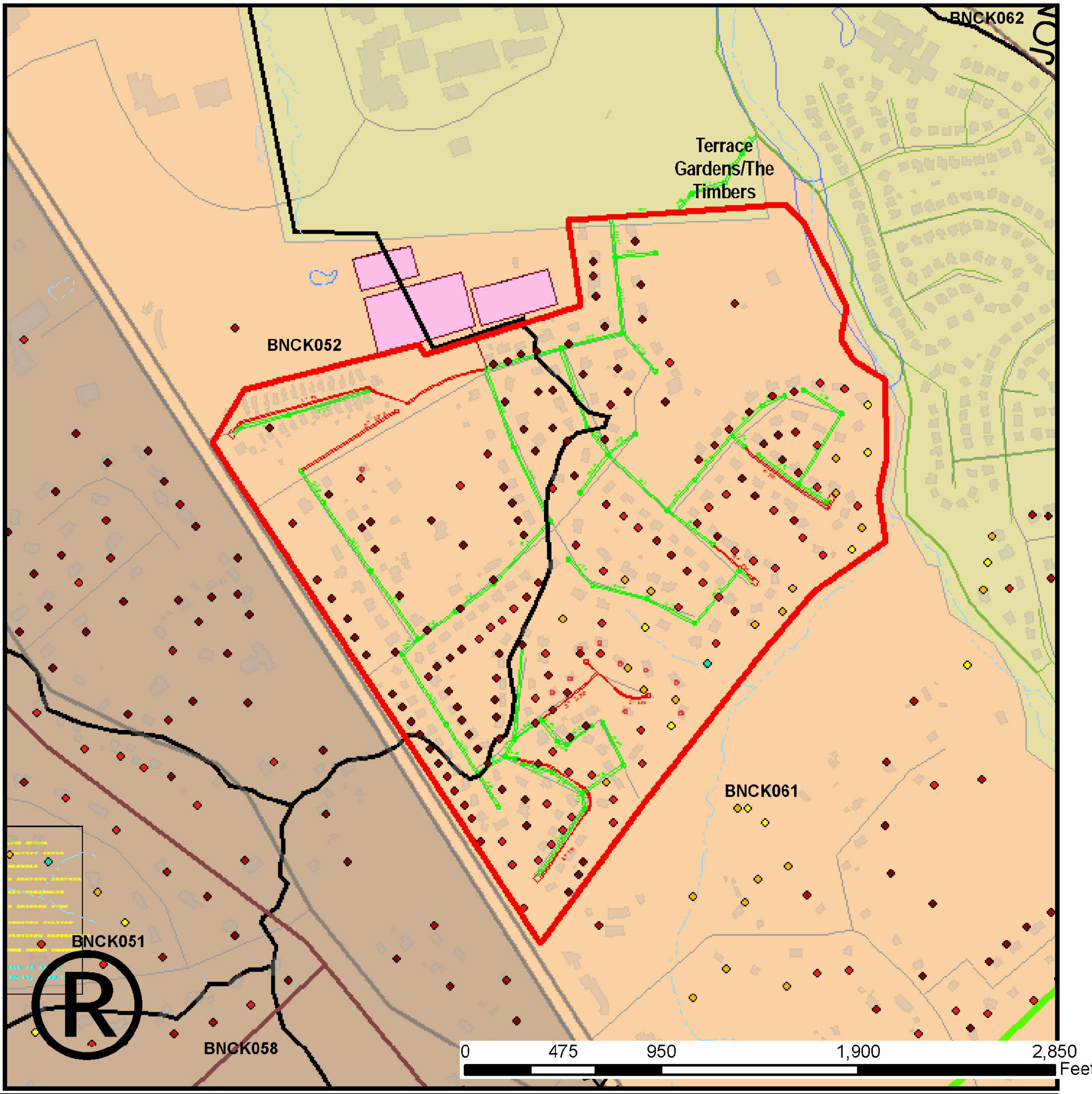

Sewer Extension and Cluster Treatment Schematic - Terrace Gardens

Legend

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- SepticProbArea
- PetitionAreas_03052007
- OSDS_Study_Area_Final
- bogs_cda
- WSSC
- Wetlands

Sewer Planning Categories

SEWER_TYPE
- Capital Facilities
- Existing Service
- Future Service
- No Public Service
- Other
- Park
- Planned Service
- Resource Conservation Area
- Water

Layer
- C-BLDG
- CTF - Piping

OSDS_priority_ranks

s_SWCCASlope
- 1.0 - 1.50
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0

Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan

CH2MHILL

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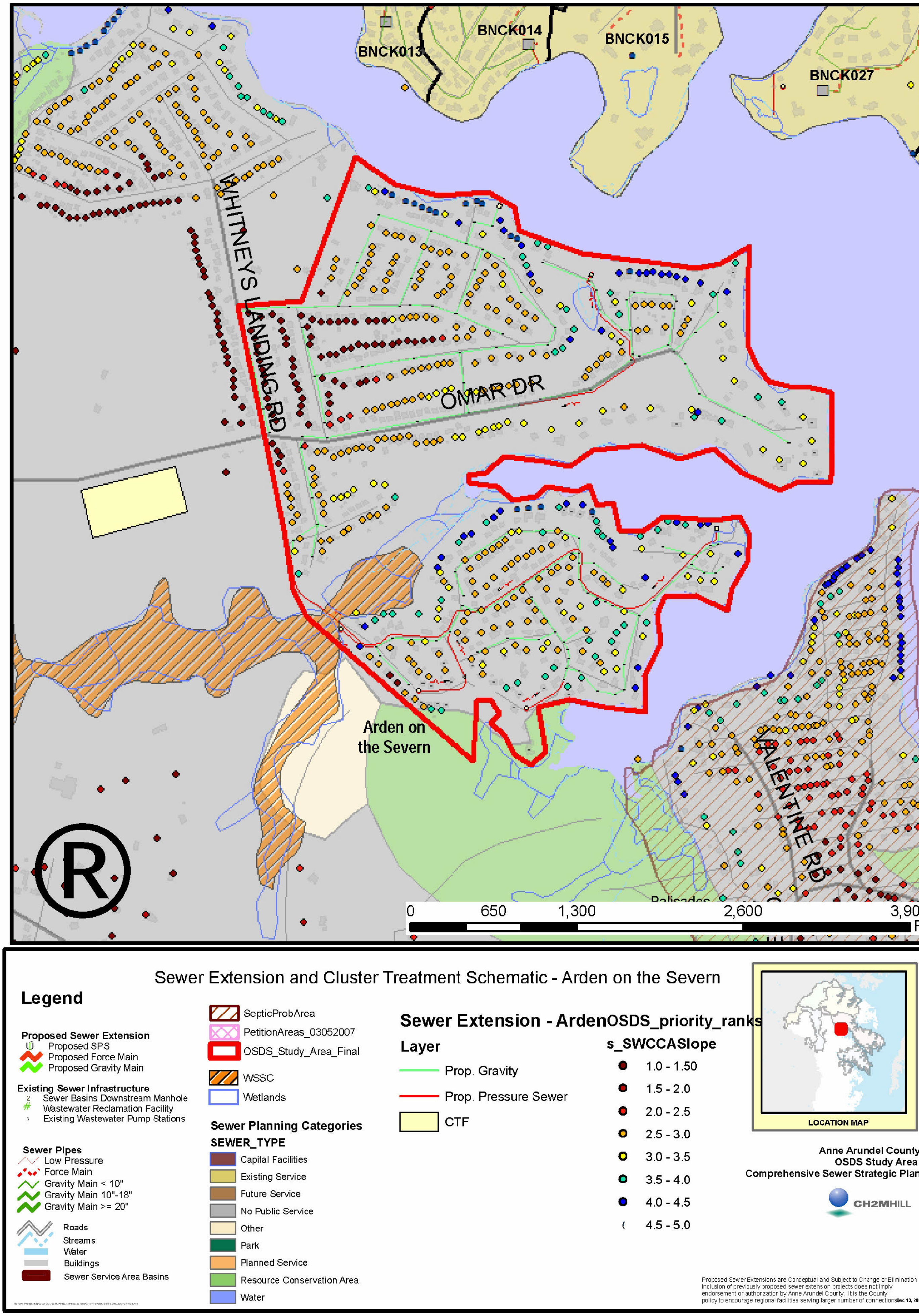
BNCK013
BNCK014
BNCK015
BNCK027
WHITNEYS LANDING RD
OMAR DR
Arden on the Severn
VALENTINE RD
0 650 1,300 2,600 3,900 Feet
Sewer Extension and Cluster Treatment Schematic - Arden on the Severn
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Sewer Extension - ArdenOSDS_priority_ranks
Layer
Prop. Gravity
Prop. Pressure Sewer
CTF
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
LOCATION MAP
Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan
CH2MHILL
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policy to encourage regional facilities serving larger number of connections.
Dec 13, 200

Sewer Extension and Cluster Treatment Schematic - Chartwell

Legend

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- SepticProbArea
- PetitionAreas_03052007
- OSDS_Study_Area_Final
- WSSC
- Wetlands

Sewer Planning Categories

SEWER_TYPE
- Capital Facilities
- Existing Service
- Future Service
- No Public Service
- Other
- Park
- Planned Service
- Resource Conservation Area
- Water

Sewer Extension - ChartwellOSDS_priority_ranks

Layer
- Prop. Gravity
- Prop. Pressure Sewer
- CTF

s_SWCCASlope
- 1.0 - 1.50
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0

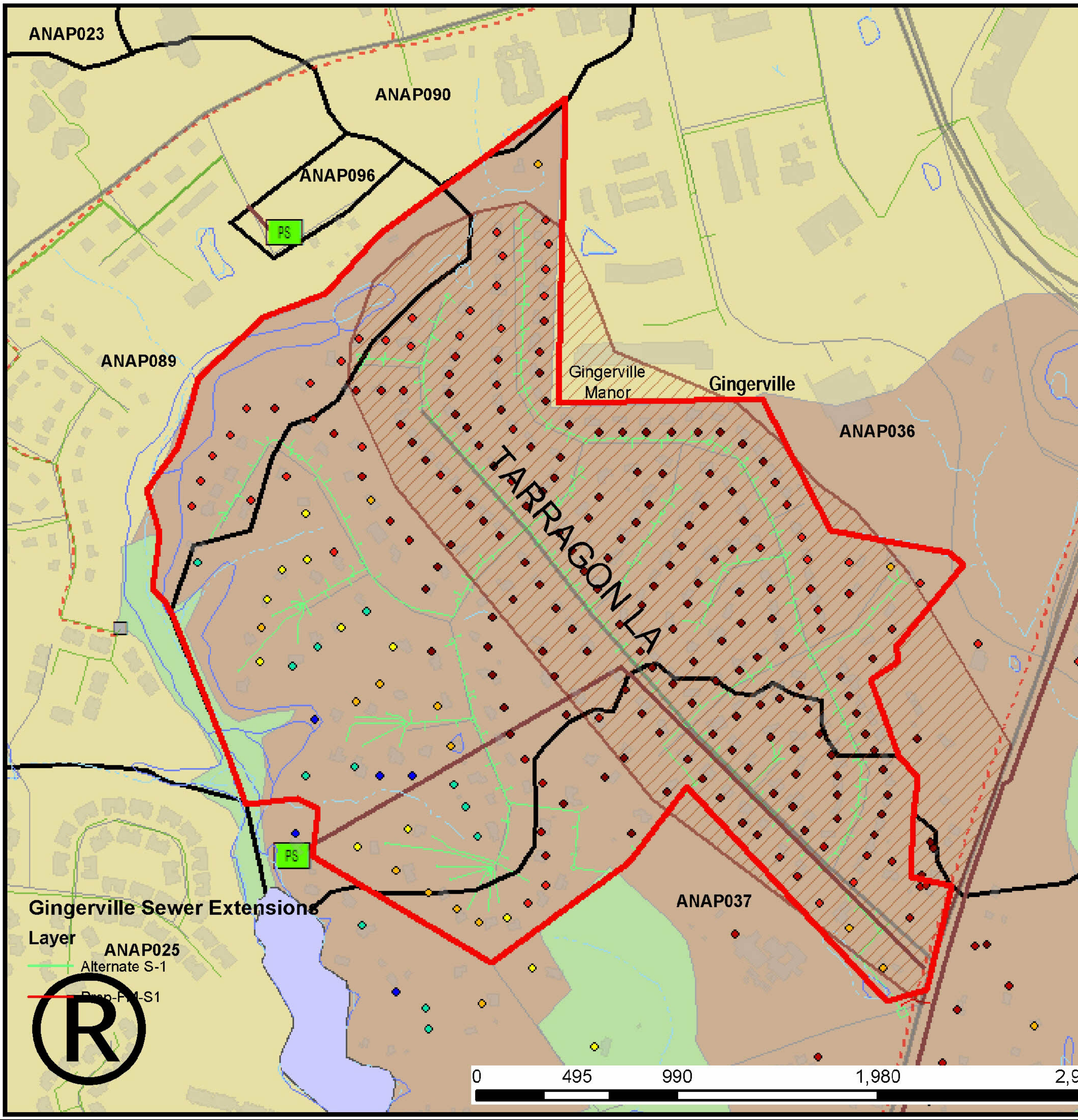
LOCATION MAP

Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan

CH2MHILL

Proposed Sewer Extensions are Conceptual and Subject to Change or Elimination. Inclusion of previously proposed sewer extensions on projects does not imply endorsement or authorization by Anne Arundel County. It is the County policy to encourage regional facilities serving larger number of connections

AR0022213



Sewer Extension and Cluster Treatment Schematic - Gingerville

Legend

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- SepticProbArea
- PetitionAreas_03052007
- OSDS_Study_Area_Final
- bogs_cda
- WSSC
- Wetlands

Sewer Planning Categories

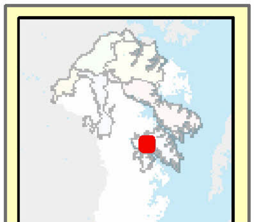
SEWER_TYPE
- Capital Facilities
- Existing Service
- Future Service
- No Public Service
- Other
- Park
- Planned Service
- Resource Conservation Area
- Water

Gingerville Sewer Extensions

Layer
- Alternate S-1
- Prop-FM-S1

OSDS_priority_ranks

s_SWCCASlope
- 1.0 - 1.50
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0



LOCATION MAP

Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan

CH2MHILL

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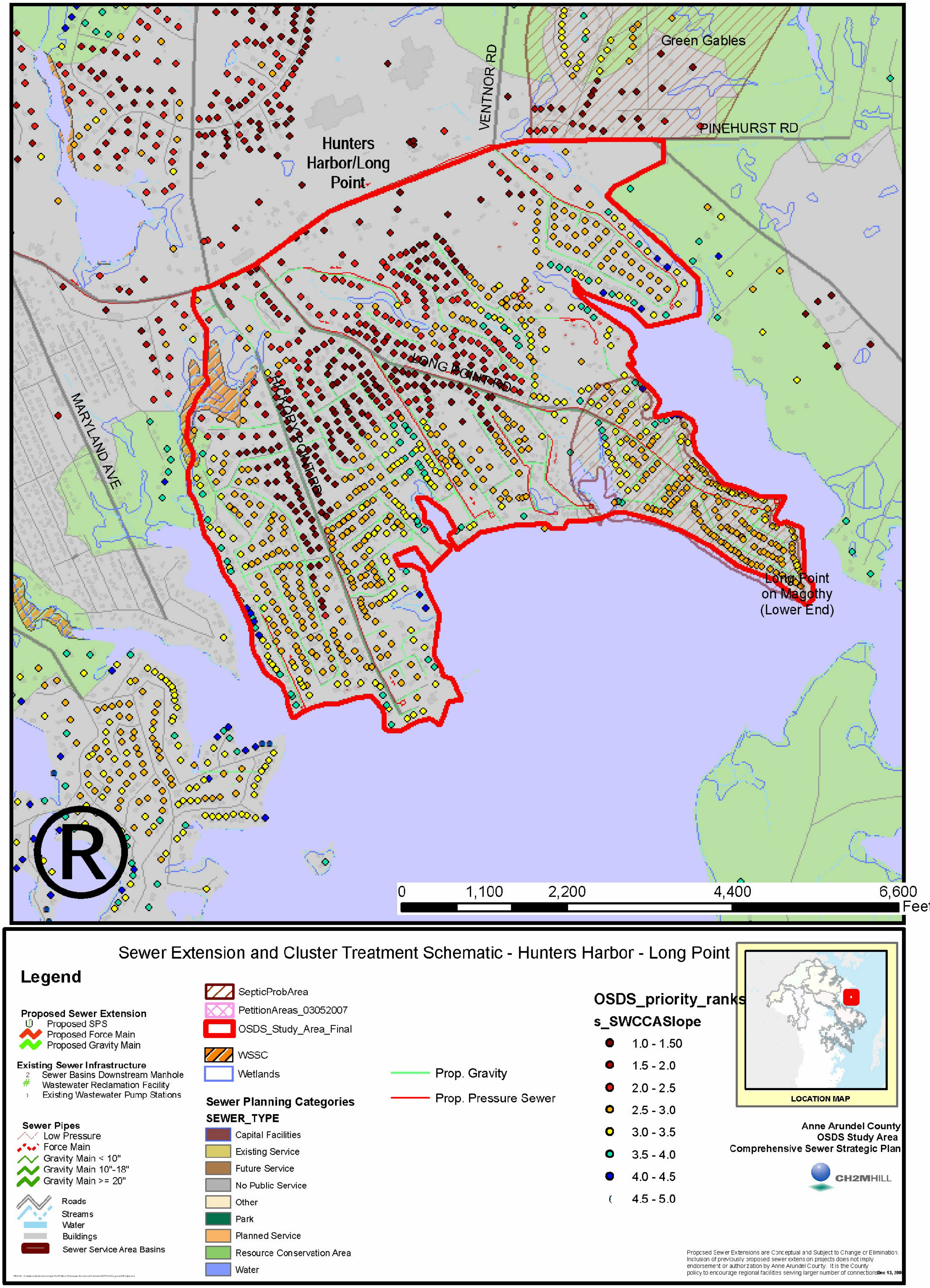
AR0022214


Green Gables
VENTNOR RD
PINEHURST RD
Hunters Harbor/Long Point
LONG POINT RD
HICKORY POINT RD
MARYLAND AVE
Long Point on Magothy (Lower End)
0
1,100
2,200
4,400
6,600
Feet
Sewer Extension and Cluster Treatment Schematic - Hunters Harbor - Long Point
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
SepticProbArea
PetitionAreas_03052007
OSDS_Study_Area_Final
WSSC
Wetlands
Sewer Planning Categories
SEWER_TYPE
Capital Facilities
Existing Service
Future Service
No Public Service
Other
Park
Planned Service
Resource Conservation Area
Water
Prop. Gravity
Prop. Pressure Sewer
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
LOCATION MAP
Anne Arundel County
OSDS Study Area
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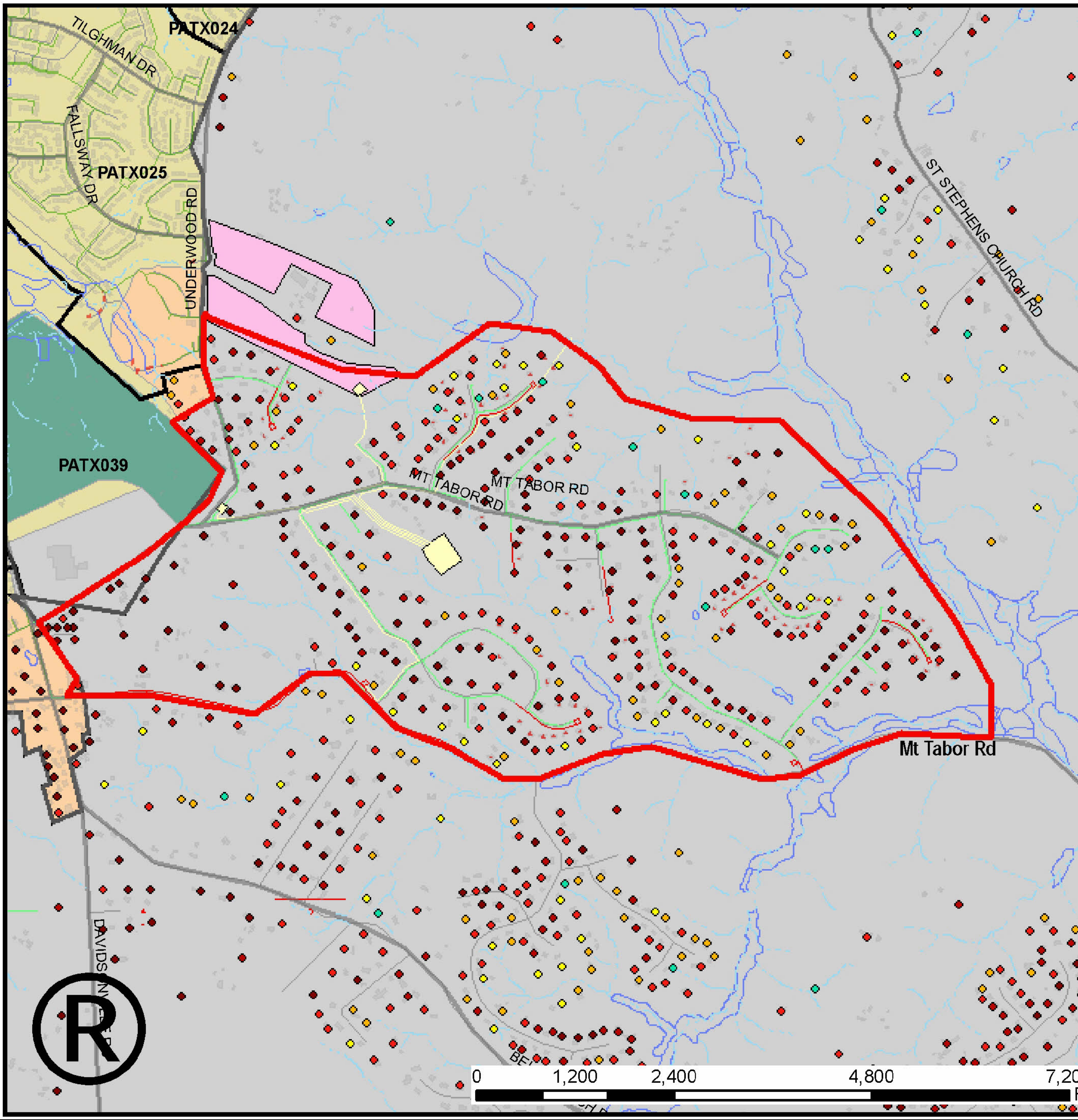

Sewer Extension and Cluster Treatment Schematic - Mt. Tabor Rd

Legend

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- SepticProbArea
- PetitionAreas_03052007
- OSDS_Study_Area_Final bogs_cda
- WSSC
- Wetlands

Sewer Planning Categories
SEWER_TYPE
- Capital Facilities
- Existing Service
- Future Service
- No Public Service
- Other
- Park
- Planned Service
- Resource Conservation Area
- Water

Sewer Extension
Layer
- Prop. Gravity
- Prop. Pressure Sewer

Cluster Treatment Facilities
Layer
- C-Disposal Area
- C-BLDG

Layer
- C-PIPE

OSDS_priority_ranks
s_SWCCASlope
- 1.0 - 1.50
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0

Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan

CH2MHILL

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Attachment E –Cluster Treatment Facility Cost Estimates

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

ARDEN OF THE SEVERN WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

	Opinion of Cost	
Item	**Land Application (SBR)**	**Direct Discharge (MBR)**
Headworks	$296,000	$450,000
Process	$1,121,000	$1,495,000
Disinfection	$162,000	$202,000
Sludge Storage	$151,000	$151,000
Effluent Disposal	$994,000	$1,322,000
Subtotal	$2,724,000	$3,620,000
Civil and Site Work @ 5%	$136,200	$181,000
Process and Yard Piping @ 5%	$136,200	$181,000
Electrical @ 15%	$408,600	$543,000
Instrumentation @ 10%	$272,400	$362,000
General Conditions @ 8%	$217,920	$289,600
Subtotal	$3,895,320	$5,176,600
Overhead and Profit @ 20%	$779,064	$1,035,320
Contingency @ 25%	$973,830	$1,294,150
Subtotal	$5,648,214	$7,506,070
Land and R.O.W Cost	$183,000	$90,000
Total Construction Cost	$5,830,000	$7,600,000

Equivalent Uniform Annual Cost		
Rate	**Cost**	**Cost**
3%	$1,076,000	$1,316,000
4%	$940,000	$1,154,000
5%	$857,000	$1,058,000

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

CHARTWELL WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

Item	Opinion of Cost	
	Land Application (SBR)	Direct Discharge (MBR)
Headworks	$450,000	$599,000
Process	$1,879,000	$2,909,000
Disinfection	$401,000	$453,000
Sludge Storage	$231,000	$231,000
Effluent Disposal	$2,466,000	$5,410,000
Subtotal	$5,427,000	$9,602,000
Civil and Site Work @ 5%	$271,350	$480,100
Process and Yard Piping @ 5%	$271,350	$480,100
Electrical @ 15%	$814,050	$1,440,300
Instrumentation @ 10%	$542,700	$960,200
General Conditions @ 8%	$434,160	$768,160
Subtotal	$7,326,450	$13,730,860
Overhead and Profit @ 20%	$1,465,290	$2,746,172
Contingency @ 25%	$1,831,613	$3,432,715
Subtotal	$10,623,353	$19,909,747
Land Cost	$570,000	$150,000
Total Construction Cost	$11,190,000	$20,060,000

Equivalent Uniform Annual Cost		
Rate	**Cost**	**Cost**
3%	$2,469,000	$3,989,000
4%	$2,119,000	$3,449,000
5%	$1,900,000	$3,118,000

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

MT. TABOR RD. WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

	Opinion of Cost	
Item	**Land Application (SBR)**	**Direct Discharge (MBR)**
Headworks	$296,000	$456,000
Process	$1,022,000	$1,304,000
Disinfection	$136,000	$154,000
Sludge Storage	$127,000	$127,000
Effluent Disposal	$2,493,000	$1,175,000
Subtotal	$4,074,000	$3,216,000
Civil and Site Work @ 5%	$203,700	$160,800
Process and Yard Piping @ 5%	$203,700	$160,800
Electrical @ 15%	$611,100	$482,400
Instrumentation @ 10%	$407,400	$321,600
General Conditions @ 8%	$325,920	$257,280
Subtotal	$5,499,900	$4,598,880
Overhead and Profit @ 20%	$1,099,980	$919,776
Contingency @ 25%	$1,374,975	$1,149,720
Subtotal	$7,974,855	$6,668,376
Land Cost	$1,320,000	$90,000
Total Construction Cost	$9,294,855	$6,758,376

Equivalent Uniform Annual Cost		
Rate	**Cost**	**Cost**
3%	$1,341,000	$1,151,000
4%	$1,189,000	$999,000
5%	$1,104,000	$908,000

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

PATUXENT MANOR WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

	Opinion of Cost	
Item	**Land Application (SBR)**	**Direct Discharge (MBR)**
Headworks	$296,000	$407,000
Process	$1,091,000	$1,444,000
Disinfection	$201,000	$201,000
Sludge Storage	$144,000	$144,000
Effluent Disposal	$117,000	$449,000
Subtotal	$1,849,000	$2,645,000
Civil and Site Work @ 5%	$92,450	$132,250
Process and Yard Piping @ 5%	$92,450	$132,250
Electrical @ 15%	$277,350	$396,750
Instrumentation @ 10%	$184,900	$264,500
General Conditions @ 8%	$147,920	$211,600
Subtotal	$2,496,150	$3,782,350
Overhead and Profit @ 20%	$499,230	$756,470
Contingency @ 25%	$624,038	$945,588
Subtotal	$3,619,418	$5,484,408
Land Cost	$120,000	$90,000
Total Construction Cost	$3,739,418	$5,574,408

Equivalent Uniform Annual Cost		
Rate	**Cost**	**Cost**
3%	$906,000	$1,202,000
4%	$765,000	$1,023,000
5%	$675,000	$911,000

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

SHADY REST ROAD WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

	Opinion of Cost	
Item	**Land Application (SBR)**	
Gravity Main	$110,000	
Process	$242,400	
Disinfection	$52,000	
Sludge Storage	$71,000	
Effluent Disposal	$479,000	
Subtotal	$954,400	
Civil and Site Work @ 5%	$47,720	
Process and Yard Piping @ 5%	$47,720	
Electrical @ 15%	$143,160	
Instrumentation @ 10%	$95,440	
General Conditions @ 8%	$76,352	
Subtotal	$1,364,792	
Overhead and Profit @ 20%	$272,958	
Contingency @ 25%	$341,198	
Subtotal	$1,978,948	
Land Cost	$420,000	
Total Construction Cost	$2,400,000	

Equivalent Uniform Annual Cost	
Rate	**Cost**
3%	$167,000
4%	$176,000
5%	$187,000

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Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

RIVERDALE WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

	Opinion of Cost	
Item		**Direct Discharge (MBR)**
Headworks		$569,000
Process		$1,978,000
Disinfection		$371,000
Sludge Storage		$177,000
Effluent Disposal		$564,000
Subtotal		$3,659,000
Civil and Site Work @ 5%		$182,950
Process and Yard Piping @ 5%		$182,950
Electrical @ 15%		$548,850
Instrumentation @ 10%		$365,900
General Conditions @ 8%		$292,720
Subtotal		$5,232,370
Overhead and Profit @ 20%		$1,046,474
Contingency @ 25%		$1,308,093
Subtotal		$7,586,937
Land Cost		$120,000
Total Construction Cost		$7,710,000

Equivalent Uniform Annual Cost		
Rate		**Cost**
3%		$1,349,000
4%		$1,196,000
5%		$1,112,000

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

SHERWOOD FOREST WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

	Opinion of Cost		
Item	**Land Application (SBR)**		
Headworks	$296,000		
Process	$1,071,000		
Disinfection	$162,000		
Sludge Storage	$151,000		
Effluent Disposal	$900,000		
Subtotal	$2,580,000		
Civil and Site Work @ 5%	$129,000		
Process and Yard Piping @ 5%	$129,000		
Electrical @15%	$387,000		
Instrumentation @ 10%	$258,000		
General Conditions (@ 8%)	$206,400		
Subtotal	$3,689,400		
Overhead and Profit (@ 20%)	$737,880		
Contingency (@25%)	$922,350		
Subtotal	$5,349,630		
Land and R.O.W Cost	$0		CTF and Land disposa
Total Project Cost	$5,350,000		located on community

Equivalent Uniform Annual Cost	
Rate	**Cost**
3%	$1,007,000
4%	$868,000
5%	$783,000

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

SHORE ACRES WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

	Opinion of Cost	
Item	**Land Application (SBR)**	
Headworks	$296,000	
Process	$1,182,000	
Disinfection	$266,000	
Sludge Storage	$151,000	
Effluent Disposal	$955,000	
Subtotal	$2,850,000	
Civil and Site Work @ 5%	$142,500	
Process and Yard Piping @ 5%	$142,500	
Electrical @ 15%	$427,500	
Instrumentation @ 10%	$285,000	
General Conditions @ 8%	$228,000	
Subtotal	$4,075,500	
Overhead and Profit @ 20%	$815,100	
Contingency @ 25%	$1,018,875	
Subtotal	$5,909,475	
Land Cost	$240,000	
Total Construction Cost	$6,149,475	

Equivalent Uniform Annual Cost	
Rate	**Cost**
3%	$877,000
4%	$791,000
5%	$747,000

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

SABRINA PARK WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

	Opinion of Cost	
Item	**Land Application (SBR)**	**Direct Discharge (MBR)**
Force Main	$208,000	$208,000
Headworks	$127,000	$127,000
Process	$773,000	$1,327,000
Disinfection	$52,000	$52,000
Sludge Storage	$71,000	$71,000
Effluent Disposal	$479,000	$1,626,000
Subtotal	$1,710,000	$3,411,000
Civil and Site Work @ 5%	$85,500	$170,550
Process and Yard Piping @ 5%	$85,500	$170,550
Electrical @ 15%	$256,500	$511,650
Instrumentation @ 10%	$171,000	$341,100
General Conditions @ 8%	$136,800	$272,880
Subtotal	$2,445,300	$4,877,730
Overhead and Profit @ 20%	$489,060	$975,546
Contingency @ 25%	$611,325	$1,219,433
Subtotal	$3,545,685	$7,072,709
Land Cost	$420,000	$90,000
Total Construction Cost	$3,965,685	$7,162,709

Equivalent Uniform Annual Cost		
Rate	**Cost**	**Cost**
3%	$506,480	$901,252
4%	$457,885	$817,631
5%	$432,924	$774,177

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

TERRACE GARDENS WASTEWATER TREATMENT PLANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

Item	Opinion of Cost	
	Land Application (SBR)	
Headworks	$296,000	
Process	$1,066,000	
Disinfection	$162,000	
Sludge Storage	$144,000	
Effluent Disposal	$940,000	
Subtotal	$2,608,000	
Civil and Site Work @ 5%	$130,000	
Process and Yard Piping @ 5%	$130,000	
Electrical @ 15%	$391,000	
Instrumentation @ 10%	$261,000	
General Conditions @ 8%	$209,000	
Subtotal	$3,729,000	
Overhead and Profit @ 20%	$746,000	
Contingency @ 25%	$932,000	
Subtotal	$5,407,000	
Land Cost	$165,000	
Total Construction Cost	$5,570,000	

Equivalent Uniform Annual Cost		
	Rate	**Cost**
	3%	$1,063,000
	4%	$917,000
	5%	$827,000

Anne Arundel County Onsite Disposal System Study
SUMMARY OF OPINION OF COSTS

BODKIN POINT COUMMINTY TREATEMENT SYSTEM REPLACEMANT
ANNE ARUNDEL COUNTY, MARYLAND
Project No. 50022

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COSTS
5/14/2007

Item	Opinion of Cost	
	Land Application	
Headworks	N/A	
Process	$247,600	
Disinfection	$52,000	
Sludge Storage	N/A	
Effluent Disposal	N/A	
Subtotal	$299,600	
Civil and Site Work @ 5%	$14,980	
Process and Yard Piping @ 5%	$14,980	
Electrical @ 15%	$44,940	
Instrumentation @ 10%	$29,960	
General Conditions @ 8%	$23,968	
Subtotal	$428,428	
Overhead and Profit @ 20%	$85,686	
Contingency @ 25%	$107,107	
Subtotal	$621,221	
Land Cost	$0	
Total Construction Cost	$620,000	

Attachment F –Natural Treatment Systems Analysis

Natural Wetlands as Treatment for On Site Sewage Systems

PREPARED FOR:	Laurens van der Tak Brian Marengo
PREPARED BY:	Jim Jordahl
DATE:	May 3, 2007
PROJECT NUMBER:	323189.S2.02

The purpose of this technical memorandum (TM) is to provide a concept level overview of the issues associated with the use of natural wetlands, especially forested wetlands, as a means providing a direct discharge for reclaimed water effluent from a cluster treatment system for Onsite Sewage Disposal Systems (OSDS) without creating a new shellfish harvesting closure area. The wetlands system would also provide some treatment in the event of an upset or problem at the OSDS that would result in much higher than normal discharge of wastewater constituents including BOD, TSS, nutrients, and pathogens. Polishing of nutrient concentrations from normal OSDS effluent is a secondary consideration, as efficient total nitrogen removal and disinfection are expected from the cluster treatment system. The value of the polishing treatment would be higher for the 8mg/L N treatment option as it would result in credits.

Executive Summary

There is a rich history of using natural wetlands for treatment, and the low energy/low maintenance benefits are readily apparent. The potential benefits include restoration of degraded wetlands and additional removal of contaminants prior to discharge to more sensitive water bodies.

The use of natural wetland systems as polishing treatment for OSDS discharges has not been well documented. Major considerations include level of pretreatment, availability of sufficient area with appropriate wetland community types, and regulatory constraints.

The Hunters Harbor area was selected as an example site for further investigation. This site was selected because other alternatives for disposal of OSDS effluent do not appear very feasible at this site. The infrastructure needed to connect to existing sewer facilities would be extensive and due to groundwater levels and soil conditions the area is not well suited for land application through a leach field or deep injection wells. Potentially suitable wetland types in terms of vegetation and hydrology were found in an area just to the west of the proposed cluster treatment system. The total land area available as wetlands (maximum of 24 acres) is small compared to the expected flows and typically recommended hydraulic loading rates for natural wetland discharges (approximately 106 to 169 acres for buildout flows).

For this application, there will be fairly complete nitrification of ammonia, removal of most of the nitrate, and disinfection to remove pathogens. Under normal operating conditions, the wetlands do not need to meet a specific treatment standard for any constituents. Therefore, the expected flows may be feasible to apply within the available wetland acreage at greater than typical hydraulic loading rate and provide a measure of safety for discharges during OSDS plant upset and the ability to provide some further polishing of nutrients during normal operations. A key factor will then become the level of ecological change that can be tolerated within the natural wetland area. Especially since the bulk of the available wetland area appears to be only seasonally flooded naturally, the ability to take portions of the system off-line would be advantageous in terms of limiting the ecological changes from increasing the hydroperiod. This approach would require a larger wetland area, on the order of 40 acres, which is more than the available acreage in the study area. It should be noted that the Hunter's Harbor area and resulting flows are considerably larger than would ordinarily be directed to an OSDS, and that more reasonably sized OSDS services areas could discharge to correspondingly smaller wetland areas. Moreover, the configuration of the most of the available wetland areas as narrow riparian borders along drainageways is not favorable for use as a treatment wetland, as residence times will be short.

Piloting a natural wetland treatment system to determine its potential applicability in other parts of the county is recommended if a suitable area could be found. A 2 acre subarea of the Hunter's Harbor wetland area was identified that may be suitable for a pilot system. Monitoring of water quality changes and changes to the ecosystem would be needed.

This TM is a very preliminary, concept-level overview. A number of issues will require more analysis to more fully evaluate this alternative, including a site investigation of the available wetland areas and a regulatory review.

Natural Wetland Types

The suitable natural wetland types for wastewater discharges are generally limited to palustrine, forested, obligate wetlands. Palustrine wetlands are inland wetlands that lack flowing water, thus providing adequate residence time. Riverine wetlands have the characteristic of water flowing through a channel, and are not suitable. Lacustrine wetlands are open water bodies that lack dense vegetation needed for treatment and prevention of algal growth, and would not be suitable. Forested wetlands are preferred for natural wetland treatment projects because the forested component helps manage algal growth. A predominance of obligate wetland plants is needed because the wetland plants need to tolerate continuous inundation.

A key question is: can the wetlands tolerate the prolonged hydroperiod needed to function as a treatment wetland? A forested swamp of obligate hydrophytes (e.g., gum, cypress) would be the preferred system. Wetlands with extensive marsh characteristics but still enough canopy to qualify as forested might also be used. A marsh system without forest characteristics could also be considered if it's densely vegetated and not tidal. If a more naturalistic hydroperiod (e.g., periodic rather than continuous inundation) is more acceptable to stakeholders, this may mean a larger total wetland area would be required to allow areas to be rested periodically. Potential changes in vegetation type need to be understood and described.

Wetland codes shown on GIS figures developed for the project were taken from the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) maps which use the Cowardin Classification system.

For Hunter's Harbor, the wetlands study area is shown in Figure 1 below within the area bounded by the ellipse. Areas of special state concern are shown by the orange cross hatched areas, and these areas could not be used as natural treatment wetlands. The NWI classification system types and land areas are shown in Table 1.

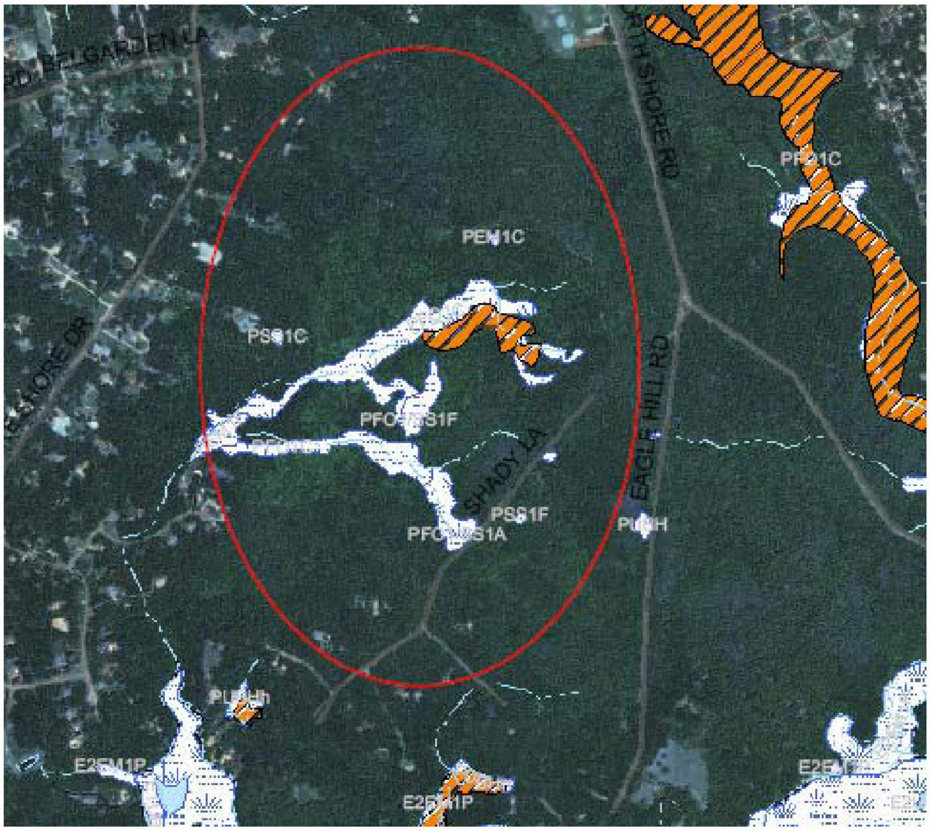


FIGURE 1
HUnter's Harbor Natural Wetland Study Area

TABLE 1
Summary of Wetland Types and Areas for Hunters Harbor Study Area

Wetland Classification	Area (ac)	Comment
PEM1C ([P] Palustrine, [EM] Emergent, [1] Persistent, [C] Seasonally Flooded)	0.13	Small, isolated area
PSS1C: ([P] Palustrine, [SS] Scrub-Shrub, [1] Broad Leaved Deciduous, [C] Seasonally Flooded)	0.17	Small, isolated area
PSS1F ([P] Palustrine, [SS] Scrub-Shrub, [1] Broad-Leaved Deciduous, [F] Semipermanently Flooded	0.12 + 0.15	Small, isolated areas
PEM1F ([P] Palustrine, [EM] Emergent, [1] Persistent, [F] Semipermanently Flooded)	1.37	
PFO1C ([P] Palustrine, [FO] Forested, [1] Broad-Leaved Deciduous, [C] Seasonally Flooded)	4.84 + 13.15	
PFO1/SS1F ([P] Palustrine, [FO] Forested, [1] Broad-Leaved Deciduous, / [SS] Scrub-Shrub, [1] Broad-Leaved Deciduous, [F] Semipermanently Flooded)	1.99	
PFO1/SS1A ([P] Palustrine, [FO] Forested, [1] Broad-Leaved Deciduous, / [SS] Scrub-Shrub, [1] Broad-Leaved Deciduous, [A] Temporarily Flooded)	2.65	
Total Area	**24.6**	
Maximum Potentially Suitable Area Based on Location	**24.0**	
Maximum Potentially Suitable Area Based on Wetland Type	**22.6**	

Therefore among the desirable criteria, all wetland areas are considered palustrine. Several areas are small and isolated and would not be feasible to use. Of the contiguous wetland areas, the majority of the area is normally only seasonally or temporarily flooded. A more continuous inundation and therefore change in the ecosystem would be required for these areas to serve as natural treatment wetlands.

Further investigation of the plant species actually present and determination of their hydroperiod (duration of inundation) would be needed to determine their suitability. The PFO1/SS1A area may be a good area for a pilot system, but the extent of the tree/shrub canopy and its ability to limit algal growth would need to be assessed.

Configuration

A design consideration is how to distribute the flow such that as much as possible of the available wetland area is used. A key consideration is that narrow natural wetland zones surrounding the perimeter of lakes or streams tend to be ineffective at water quality improvement due short circuiting of the flow through the wetland (Kadlec and Knight, 1996). At least two separate sites not hydraulically connected is the ideal, such that dry periods can be imposed periodically to favor growth and propagation (Kadlec and Knight, 1996). Landform types that are considered suitable in the southeastern U.S. include cypress domes, oxbow sloughs, and Carolina bays (Kadlec and Knight, 1996). Boardwalks supporting gated pipe systems with numerous outlets are typically used rather than single point inlets (Kadlec and Knight, 1996). There is no minimum flow path length, but long residence times are important. A desirable length to width ratio is 2:1 or 3:1.

In the Hunter's Harbor area shown in the previous figure, the majority of the wetland areas appear to be narrow riparian areas bordering drainageways. Narrow strips of wetlands are not suitable because the travel path and therefore residence time is too short, however, the 2 acre area of PFO1/SS1A based on configuration may be a good area to site a pilot.

Pathogen Removal

Wetlands have been found to reduce human pathogen populations because of natural die-off rates and hostile environmental conditions (Kadlec and Knight 1996). Indicator organisms, or fecal coliforms, are typically monitored to estimate pathogenic organisms present in wastewaters. Typically, fecal coliform removal efficiency can be estimated using an area-based first order degradation model. Pilot system monitoring would provide data to calculate site-specific first-order model coefficients for fecal coliform removal.

Particle removal is the first stage of pathogen removal in treatment wetlands, through sedimentation, surface adhesion, and aggregation. The second stage is a series of other processes such as environmental conditions (temperature, pH, redox, etc.), predation, infection, and competition with other microorganisms, and UV exposure. All of these processes are optimized by uniform flow paths and long detention times.

Nitrogen Loading

Projections for nitrogen concentrations in the OSDS effluent are as follows:

Direct Discharge

- Total Nitrogen < 4 mg/L
- NH_3-N < 1.0 mg/L
- (NO_2-N / NO_3-N) < 1.0 mg/L
- Organic Nitrogen < 2.0 mg/L

Land Application:
- Total Nitrogen < 8 mg/L
- NH_3-N < 1.0 mg/L
- (NO_2-N / NO_3-N) < 5.0 mg/L
- Organic Nitrogen < 2.0 mg/L

A summary of recommended minimum pretreatment levels for discharges to natural wetlands is provided in Table 2. Clearly the projected nitrogen loading will be well within recommended limits. Ammonia nitrogen is especially important, in that can lead to oxygen depletion and un-ionized ammonia toxicity. Some data suggests that NH_4-N and BOD_5 loading are more likely to cause negative impacts than increased hydraulic loading rates (Knight et al., 1987 as cited in Kadlec and Knight, 1996).

TABLE 2
Summary of Recommended Pretreatment Ranges for Natural Wetlands
Kadlec and Knight (1996)

Constituent	Suggested
BOD_5	Min. of Secondary (20-30 mg/L)
TSS	Min of Secondary (30-50 mg/L)
NH_4-N	Max. of 5 mg/L
Total N	<20 mg/L
Total P	<1.0 mg/L
Metals and Other Toxins	Below chronic toxicity

Ecological Impacts

Changes to the natural wetland ecosystem need to be considered in the design and monitoring program. The goal is typically to minimize impacts including changes to the existing mixture of vegetation. With any change in hydroperiod, hydraulic loading rate, or constituent loading rates, the ecosystem will change to some degree (slight to significant) in response, and this change may occur over long time frames (decades).

Flows and Area Requirements

Natural wetlands are typically loaded at low, conservative rates relative to treatment wetlands, generally at a hydraulic loading rate of less than 0.5 cm/day (0.2 in/day). An initial range for acreage requirements are shown in Table 3 based the estimated flow for the Hunter's Harbor study area hydraulic loading rate. The lower end of the range would be more appropriate if nitrification pretreatment is limited, and the higher rate likely more appropriate for a more fully nitrified effluent such as the OSDS effluent.

TABLE 3
Conservative Approximation of Acreage Requirements for Hunter's Harbor Area OSDS Flows

Flow Estimate	Hydraulic Loading Rate - Typical		Hydraulic Loading Rate - Aggressive
	0.25 cm/day (0.1 in/day)	0.4 cm/day (0.16 in/day)	2.1 cm/day (0.83 in/day)
Existing OSDS (278,750 gpd)	104	65	12
Ultimate (452,023 gpd)	169	106	20

These projected areas for typically recommended loading rates for natural wetland systems are considerably greater than the available wetland areas for Hunter's Harbor shown in Figure 1. Area requirements for natural wetland systems should also include provisions for resting periods to favor propagation of woody species.

Considerably higher hydraulic loading rates (several cm/day) may be possible for some situations, especially if the existing natural wetland is significantly degraded or would benefit from increased flows to recreate more natural conditions, and influent water quality (especially BOD_5 and NH_4-N) is favorable. With the projected OSDS effluent, pretreatment ahead of the wetlands is good, with low levels of total nitrogen and particularly NH_4-N. An aggressive loading rate of 2.1 cm/day is also shown in the table, and resulting wetland areas would fit within the available area shown in Figure 1. These hydraulic loading rates would probably be feasible given the high quality OSDS effluent, and lack of specific treatment targets for wetland effluent. A typical dense emergent marsh constructed treatment wetland would still achieve excellent nitrate nitrogen removal (~90 percent) at these loading rates, however, as a general rule, loading rates in this range are not acceptable for natural wetland systems.

Level of Treatment Expected

The major issues for effluent treatment are typically nitrogen and phosphorus, but in this case, the major issue will be treatment of pathogens, as nutrients will be addressed by the cluster treatment system. Although of secondary importance, additional removal of 75 percent or more of the OSDS effluent nitrogen would likely occur in a well designed system.

Pathogens

When wetland inflow fecal coliform (FC) levels are higher than typical for treated municipal wastewater that have not received disinfection, wetland removal efficiencies are nearly always greater than 80 to 90 percent (Kadlec and Knight 1996). However, because of the natural sources of coliforms in all wetlands open to wildlife, wetlands have a background fecal coliform level (C*) of approximately 500 col/100mL (Kadlec and Knight, 1996). Systems that are more attractive to birds may be more problematic (open water, trees). The OSDS will have a UV disinfection system that will reduce FC to less than 14 MPN/100mL

(Most Probable Number). Therefore it is likely that as the effluent passes through the natural wetland the FC will likely rise to background levels of 500 col/100mL, however the FC will be predominantly of animal rather than human origin.

Nitrogen

Nitrogen fate depends largely on the form of influent nitrogen. With a well-nitrified effluent, removals of 75 percent or (typically) more would occur through denitrification. If influent contains considerable ammonia, then the wetland needs to transform it to nitrate first, and this occurs at a much slower rate than denitrification in wetlands. The atmosphere will be the sink for the N_2 produced during denitrification.

Most of the residual nitrogen not released to the atmosphere will be stored in the sediment, and some of that nitrogen gets recycled into the plant tissue and then back to the sediment annually. Increased rates of biomass accumulation are likely in response to the increased nutrient loading, but if the hydraulic and mass loading remains small, then this is not a significant issue. Long term studies (20 to 30 yrs) show no deterioration of N removal rates in treatment wetlands.

Preliminary model results suggest that with the higher ("Land Application") nitrogen concentrations (<8 mg/L), buildout flows of 452,000 gpd, a 2.1 cm/day hydraulic loading rate, and a 20 acre wetland area, total nitrogen would be reduced from 8 mg/L to 2.5 mg/L, and NO3-N would be reduced from 5 mg/L to 0.6 mg/L.

Phosphorus Removal

The state of the art in assessing phosphorus loadings to wetlands is provided in Kadlec (1999). Long term phosphorus removal is limited by the net burial of recalcitrant residuals created by the biogeochemical cycle. Wetlands show an "S" curve response to increasing phosphorus loadings, with a lower plateau defined by background concentrations (10 to 50 µg P/L), and the upper plateau is the inlet concentration, representing no phosphorus removal. A first order mass balance equation is used:

$$C_o = C_* + (C_i - C_*) \times \exp(-(kC_i/PL_i))$$

where C_o is outlet phosphorus, C_i is inlet phosphorus, C_* is background phosphorus, PL_i is the phosphorus loading rate, and k is the first order rate constant (m/yr).

High initial rate of removal or "luxury" uptake may occur because of sorption to sediments, the capacity of which is generally exhausted in months, and biomass uptake, with net removals ceasing after 1 to 6 years. The concentration of phosphorus in effluent is a function of influent flow and phosphorus concentration. Below a loading rate of 0.1 to 10 g P m^{-2} yr^{-1}, there is no downstream impact of the wetland. Above a loading rate of 4 to 1400 g P m^{-2} yr^{-1}, no water quality improvement from inlet concentrations can be expected. Individual wetland characteristics determine actual performance within these ranges. Some wetlands are large enough that outlet concentrations remain at background levels for very long periods. Rate constants between 5 and 15 m yr^{-1} are commonly used, with an average of 10 m yr^{-1} commonly applied. Outlet concentrations are likely to begin to exceed background levels (5 to 50 µg P/L) at a loading rate between 0.1 to 10 g P m^{-2} yr^{-1}. Table 4 provides example bounds for the function, using a typical k value of 10 m/yr.

TABLE 4
Location of "Knees" on Phosphorus Loading Curves (adapted from Kadlec, 1999)
(Phosphorus loadings for upturn and leveling off points are given in the two right columns)

Model Parameters			Lower Knee	Upper Knee
k (m/yr)	**C_* (mg P/L)**	**C_i (mg P/L)**	**PL_i g P m^{-2} yr^{-1}**	**PL_i g P m^{-2} yr^{-1}**
10	0.02	0.10	0.27	7.49
10	0.02	10.00	11.74	947

Note: PL_i represents the inlet phosphorus loading rate

Figure 2 shows a schematic of the general relationship of phosphorus loading to outlet concentrations.

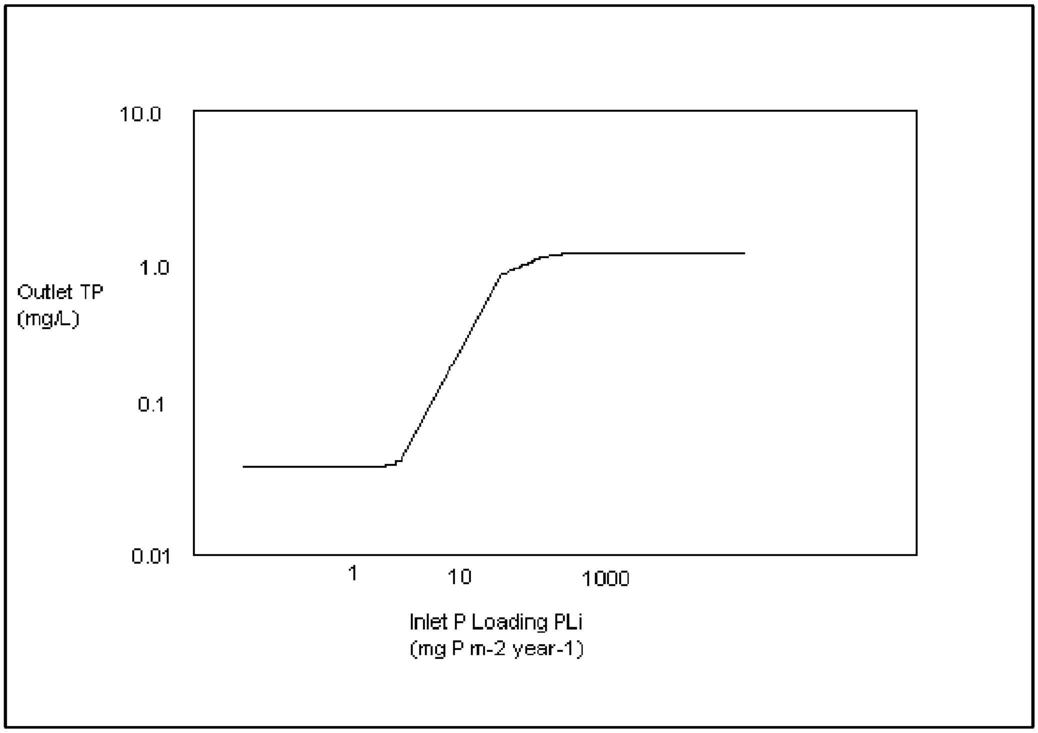


FIGURE 2
1st Order Model for Outlet Phosphorus Concentrations as a Function of Loading

Wetlands are not particularly efficient at phosphorus removal, and require relatively large areas. Two processes are key for phosphorus removal: sedimentation of particulate phosphorus and sorption of soluble phosphorus. Storage and effluent phosphorus varies in both space and time. The startup period for effective phosphorus removal may be 1 to 5 years. The general equation often used for phosphorus removals is based on first order kinetics, $\ln(Co/Ci) = k/q$, with an average value for emergent and subsurface flow wetlands of 11.5 m/yr (Kadlec and Knight, 1996). Rate constants, influent, and effluent concentrations for wetlands in the Great Lakes region are shown in Table 5.

TABLE 5
Wetlands Removal Rates and "k" Values for Wetlands in or Near the Great Lakes Region

Site	No. of Wetlands	Years operation	Data years	HLR (cm/d)	TP in (mg/L)	TP out (mg/L)	k value (m/yr)
Des Plaines, IL	4	6	6	4.77	0.10	0.02	23.7
Fontanges, Quebec	1	2	2	5.6	4.15	2.40	11.2
Houghton Lake, MI	1	16	16	0.44	2.98	0.10	11.0
Cobalt, Ontario	1	2	2	7.71	1.68	0.77	20.9
Brookhaven, NY	1	3	3	1.5	11.08	2.33	8.9
Listowel, Ontario	5	4	4	2.41	1.91	0.72	8.2

Operations and Maintenance

No "demucking" of a treatment wetland is necessary for treatment to be maintained; it is more important to track and maintain the hydraulics of the system to prevent preferential flow channels from developing.

Regulatory Issues

The study area is good example of how the concept of ultimate disposal becomes a difficult question both from a regulatory and technical standpoint. Although wetland treatment could be effective in this case, there are regulatory issues that would require further discussion and evaluation. In most states, a discharge to a wetland is the same thing as a discharge to waters of the State, and the discharge has to meet water quality criteria (unless, as in the case of South Carolina and Florida) there are rules assigning other criteria within and in the wetland-treated water for natural treatment wetlands.

The Maryland Department of the Environment (MDE) is responsible for identifying and regulating "Wetlands of Special State Concern" (WSSC). The primary concern for regulators is bogs, which the state and county have mapped separately from the NWI. Additional information, determined from field inspections, is used to identify and classify these areas. The Maryland Department of Natural Resources uses this WSSC data for site and regulatory application reviews, management plans and other uses. In 1988-89, Maryland DNR (then responsible for identifying and protecting WSSC's) contracted with Salisbury State University to produce Wetlands Guidance maps that contained Wetlands of Special State Concern (WSSC). Digital WSSC files were produced as part of that effort. In 1997, with new WSSC's identified in COMAR, Maryland DNR began the process of creating an updated file and producing a new series of guidance maps. The WSSC GIS layer was overlaid combined with the NWI Wetlands and Anne Arundel County Bogs layer in Attachment 2 to determine which wetlands require special consideration.

Economics

The economic feasibility will in part be driven by the need to buy the wetlands or otherwise obtain an easement. Ideally, we might be able to locate a hydrologically altered (e.g., channelized, ditched, drained, etc) wetland where more flow would be acceptable and even welcome.

The costs for natural wetland systems vary widely. Costs for treatment wetlands in the 25 to 50 acre average approximately $50,000 per acre for design and construction. This does not include land acquisition costs or monitoring. Costs for mitigation wetlands are of a similar order of magnitude. Natural wetland treatment systems generally have less extensive earthmoving requirements, but requirements for site investigations, regulatory negotiations, and monitoring can be considerable. Major components would include conveyance from the OSDS to the wetland area, a gated pipe distribution system and support structure such as boardwalk, valving to control flows to different wetland sections, and berms and outlet structures to control water levels. The same $50,000/ac figure is suggested for initial planning purposes, but it should be recognized that site specific issues may have a large impact on costs.

Operations and maintenance costs are low for natural treatment systems, as the main energy source is solar radiation, and no chemical inputs are required. The major cost components are pumping energy, berm, vegetation, inlet/outlet structure maintenance, and monitoring water quality and ecosystem changes. Relatively little data has been compiled and documented on natural wetland treatment systems O&M costs. Site specific requirements for monitoring will be an especially important component. For a 100 acre system, total O&M costs may be on the order of $50,000 to $150,000 per year.

Pilot System

Assuming a regulatory path forward can be found, a well-designed pilot would be the best means of further evaluating a natural wetlands treatment system for pathogen removal and further polishing of nutrients remaining in the treated OSDS effluent. The pilot system would allow calibration of the treatment model and development of local, wetland-specific rate constants, and would help build acceptance by stakeholders. Furthermore, this system might result in additional nitrogen treatment credits, which could hold value in the basin wide nutrient management strategy.

Other Potential Constraints

Other potential constraints include property ownership, water quality standards, adjacent receiving waters, presence of threatened or endangered plant or animal species, cultural resources, and public/political opposition (Kadlec and Knight, 1996).

References

Kadlec, R.H. and R.L. Knight. 1996. Treatment Wetlands. Lewis Publishers, Boca Raton, FL.

Kadlec, R.H. 1999. The limits of P removal in wetlands. Wetlands Ecol. Manag. 7:165-175.

Attachments

Attachment 1 – Hunters Harbor Study Area with OSDS sites Wetlands of Special State Concern, and AACo Bogs

Attachment 2 – Palustrine wetland areas evaluated for treating cluster treatment facility effluent

Examples

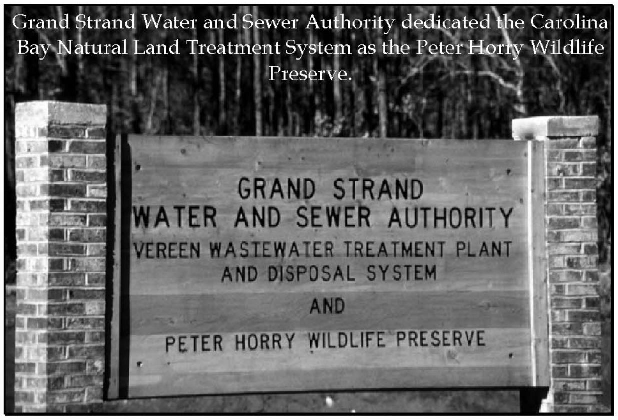
Carolina Bay Effluent Disposal Studies, Design, and Monitoring Grand Strand Water and Sewer Authority Conway, South Carolina

In 1991, CH2M HILL was awarded the Grand Conceptor Award by the American Consulting Engineers Council for the design of the Carolina Bay effluent disposal system.

CH2M HILL conducted site-specific studies at 10 Carolina Bay freshwater wetlands in Horry County, South Carolina, to assess their suitability for municipal effluent treatment and disposal. Field studies included vegetation analyses, mapping, faunal surveys, inventories of threatened and endangered species, evaluation of substrate cores, and surface and groundwater quality analyses. To predict advanced treatment potential and probable ecological effects, the project team compared reported treatment efficiencies and characteristics of other wetland effluent disposal sites with the observed properties of the Carolina bays. The site-specific findings were used to rank the Carolina bays and to select two sites for use as natural land treatment systems. Throughout this study, CH2M HILL coordinated with the client, local political decision-makers, the press, and state and federal regulatory agencies.

After the study plans were approved, CH2M HILL conducted a full-scale operational pilot study to monitor the use of a Carolina bay for natural land wastewater treatment and disposal. A 160-acre bay known as Bear Bay received treated domestic wastewater via a gated-pipe effluent distribution system designed by CH2M HILL. This water sheet-flowed for about one-half mile through the wetland forest to an outlet channel, where it was monitored for flow rate and water quality. Other surface water quality monitoring points were spaced along the direction of flow and in background areas. A network of monitoring wells was also used to determine the effects of the system on groundwater. Detailed botanical and wildlife studies have been conducted annually since 1986.

Operational data were compared to baseline data to develop a detailed design for the full-scale natural land treatment system. The current program incorporates about 700 acres of Carolina bays into a multiuse effluent management and nature study park concept.



Grand Strand Water and Sewer Authority dedicated the Carolina Bay Natural Land Treatment System as the Peter Horry Wildlife Preserve.

Gated pipes on raised boardwalks allow access to over 600 acres of treatment area in the Carolina Bay Natural Land Treatment System in South Carolina.

Wastewater Wetland Sites in Florida

There are essentially two general types of domestic wastewater wetlands - natural and man-made (constructed) wetlands. Chapter 62-611, Florida Administrative Code (FAC), wastewater to wetlands rule, breaks natural wetlands into receiving and treatment wetlands. The difference between the two is explained below. For permitted purposes the wastewater to wetlands rule further classifies natural wetlands as hydrologically-altered or not. The intent of classifying certain wastewater wetlands as hydrologically-altered is to restore or prevent a previous or potential loss of wetland acreage. The use of hydrologically-altered wetland as well as creating wetlands for effluent polishing are both considered reuse of reclaimed water activities, according to Chapter 62-610, FAC.

Some domestic wastewater facilities utilize a combination of more than one of these types, typically man-made wetlands and natural wetlands. There are 16 natural (both treatment and receiving) wastewater wetlands comprising roughly 6,200 acres and a total of 19 constructed wetland sites comprising roughly 4,000 acres across Florida. Of those, 4 facilities use a combination of both natural and constructed wetland systems, making that a total of 31 permitted domestic wastewater wetland sites in the state of Florida. A complete list of these wastewater wetlands sites is provided below according to their classification.

Natural Receiving Wetlands

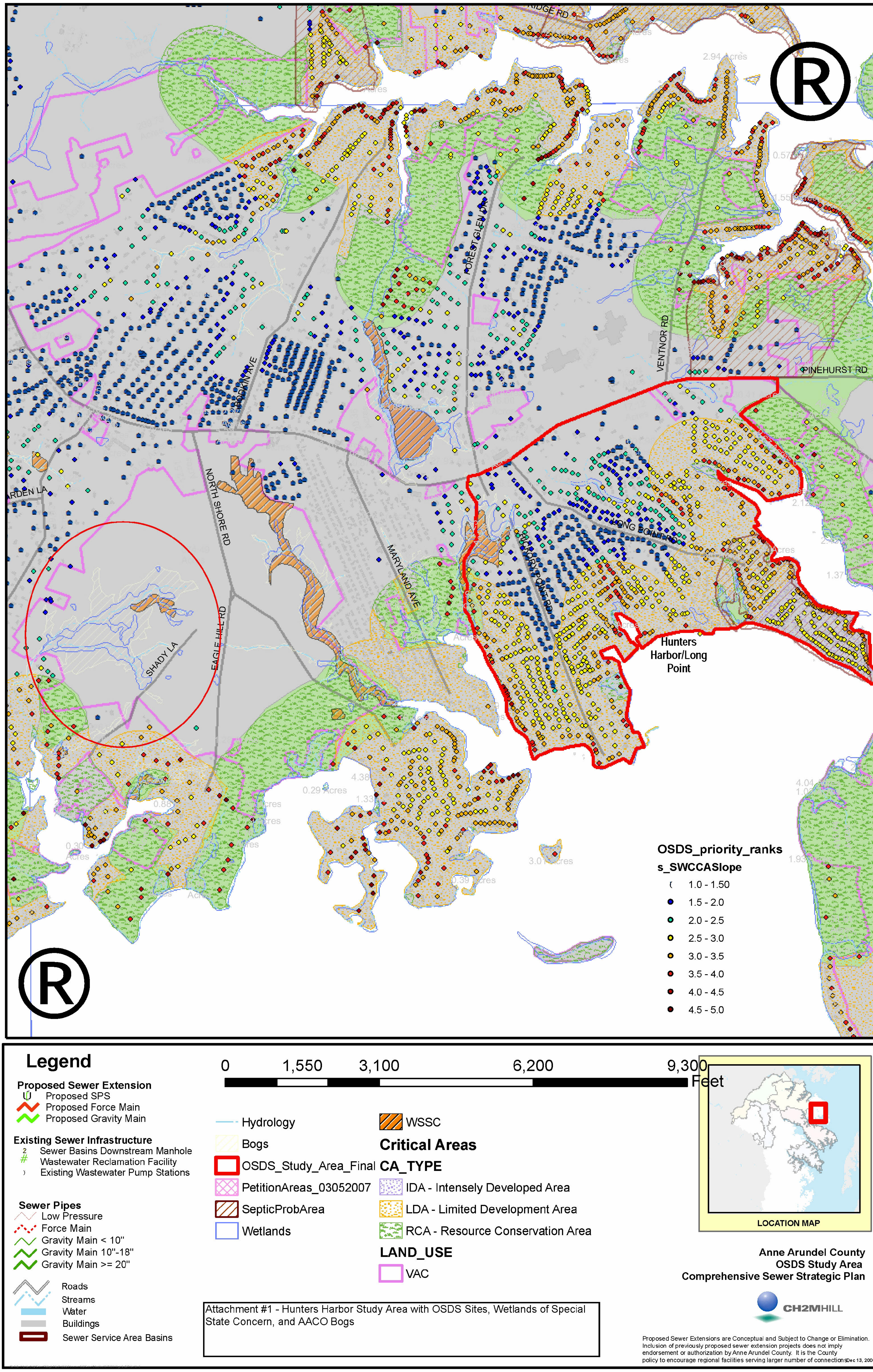
Receiving wetlands receive the highest level of treatment - advanced waste treatment (AWT) standards. This is equivalent to not more than, on an annual average basis, 5 mg/L of CBOD, 5 mg/L of TSS, 3 mg/L of TN and 1 mg/L of TP, along with basic disinfection.

- Baisden Swamp, City of Jasper WWTP (since 1914)
  Permitted for 1.2 MGD, approx. 218 acres of freshwater, forested wetlands
- Bayou Marcus Wetlands (since 1998)
  Bayou Marcus Water Reclamation Facility, ECUA
  Permitted for 8.2 MGD to approx. 1,100 acres of freshwater, forested wetlands
- Blacks Ford Swamp (since 1999)
  Blacks Ford Regional WWTF (formerly St. Johns County North), United Water Florida
  Permitted for 0.49 MGD to approx. 311 acres of freshwater, forested wetlands
- East Bay Swamp (since 1996)
  Hurlburt Field Advanced WWTF, US Air Force
  Permitted 1.0 MGD to approx. 700 acres of freshwater, forested wetlands
- Huckleberry Swamp, City of Apalachicola WWTP (since 1985)
  Permitted for 1.0 MGD to approx. 243 acres of freshwater, scrub-shrub wetlands
- Isolated Receiving Wetland Reuse Site (since 1999)
  East Central Regional WWTF, City of West Palm Beach
  Permitted for 6 MGD to approx. 1,458 acres of wet prairies (part of the Loxahatchee Slough) and 323 acres of woody restoration wetlands
- Leesburg WWTF (since 1997)
  Permitted for 0.57 MGD to approx. 500 acres in the Okahumpka Swamp
- Port of the Islands South (since 1994)
  Permitted for 1.2 MGD to approx. 35 acres of cypress dome wetlands
- Yulee Swamp, Yulee Regional WWTF (since 1996)
  Permitted for 0.5 MGD to approx. 350 acres of mixed deciduous swamp

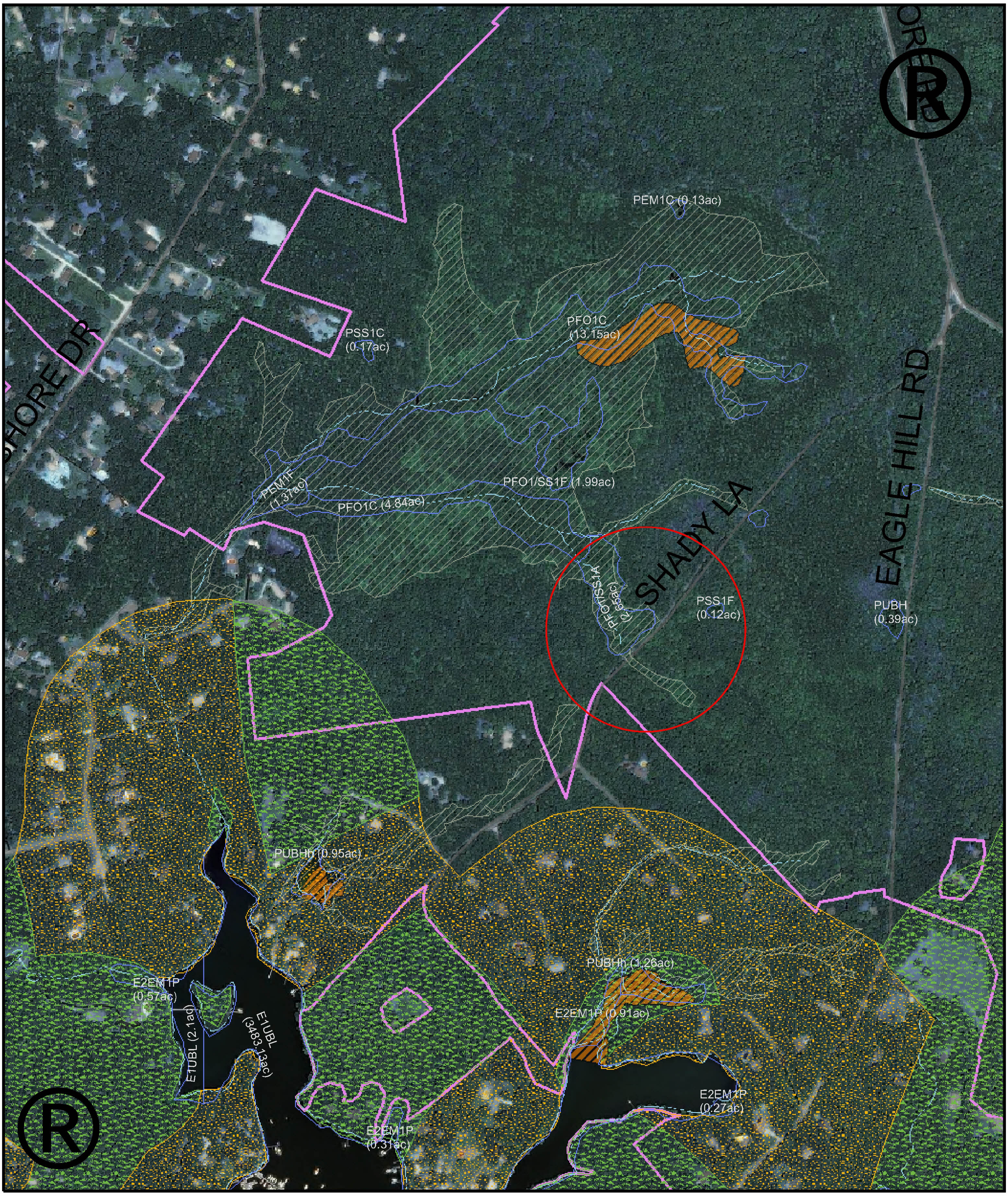
Natural Treatment Wetlands

Treatment wetlands must receive effluent that has been treated to at least secondary standards (20 mg/L of CBOD and 20 mg/L of TSS) with nitrification and basic disinfection. Monitoring standards within a treatment wetland are more extensive and frequent to ensure that the type, nature and function of the wetland is being protected.

- Boot Wetland Treatment System, Poinciana Utilities (since 1985)
  Permitted for 0.35 MGD to approx. 115 acres of cypress-gum wetlands
- Deer Park Wetlands (since 1988)
  Deer Park Subregional Reuse Facility, Pasco County Utilities Department
  Permitted for 1.2 MGD to approx. 146 acres of cypress dome wetlands
- Pace Swamp, Pace Water Systems, Inc. (since 1999)
  Permitted for 1.0 MGD to approx. 140 acres of freshwater, forested wetlands



RIDGE RD
2.94 Acres
0.57
1.55
FOREST GLEN DR
VENTNOR RD
PINEHURST RD
BODKIN AVE
NORTH SHORE RD
ARDEN LA
MARYLAND AVE
LONG POINT RD
HICKORY POINT RD
EAGLE HILL RD
SHADY LA
Hunters
Harbor/Long
Point
2.12
1.37
4.38
0.29 Acres
1.33
0.88
0.30
3.01 Acres
0.39 Acres
4.04
1.93
OSDS_priority_ranks
s_SWCCASlope
1.0 - 1.50
1.5 - 2.0
2.0 - 2.5
2.5 - 3.0
3.0 - 3.5
3.5 - 4.0
4.0 - 4.5
4.5 - 5.0
Legend
Proposed Sewer Extension
Proposed SPS
Proposed Force Main
Proposed Gravity Main
Existing Sewer Infrastructure
Sewer Basins Downstream Manhole
Wastewater Reclamation Facility
Existing Wastewater Pump Stations
Sewer Pipes
Low Pressure
Force Main
Gravity Main < 10"
Gravity Main 10"-18"
Gravity Main >= 20"
Roads
Streams
Water
Buildings
Sewer Service Area Basins
0
1,550
3,100
6,200
9,300
Feet
Hydrology
Bogs
OSDS_Study_Area_Final
PetitionAreas_03052007
SepticProbArea
Wetlands
WSSC
Critical Areas
CA_TYPE
IDA - Intensely Developed Area
LDA - Limited Development Area
RCA - Resource Conservation Area
LAND_USE
VAC
LOCATION MAP
Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan
CH2MHILL
Attachment #1 - Hunters Harbor Study Area with OSDS Sites, Wetlands of Special State Concern, and AACO Bogs
Proposed Sewer Extensions are Conceptual and Subject to Change or Elimination. Inclusion of previously proposed sewer extension projects does not imply endorsement or authorization by Anne Arundel County. It is the County policy to encourage regional facilities serving larger number of connections.
Dec 13, 2006



Legend

0 480 960 1,920 2,880 Feet

Proposed Sewer Extension
- Proposed SPS
- Proposed Force Main
- Proposed Gravity Main

Existing Sewer Infrastructure
- Sewer Basins Downstream Manhole
- Wastewater Reclamation Facility
- Existing Wastewater Pump Stations

Sewer Pipes
- Low Pressure
- Force Main
- Gravity Main < 10"
- Gravity Main 10"-18"
- Gravity Main >= 20"

- Roads
- Streams
- Water
- Buildings
- Sewer Service Area Basins

- Hydrology
- Bogs
- OSDS_Study_Area_Final
- PetitionAreas_03052007
- SepticProbArea
- Wetlands

- WSSC

Critical Areas

CA_TYPE
- IDA - Intensely Developed Area
- LDA - Limited Development Area
- RCA - Resource Conservation Area

LAND_USE
- VAC

LOCATION MAP

Anne Arundel County
OSDS Study Area
Comprehensive Sewer Strategic Plan

Attachment #2 - Palustrine Wetland Areas Evaluated for treating cluster treatment facility effluent

CH2MHILL

Proposed Sewer Extensions are Conceptual and Subject to Change or Elimination. Inclusion of previously proposed sewer extension projects does not imply endorsement or authorization by Anne Arundel County. It is the County policy to encourage regional facilities serving larger number of connections. Dec 13, 2006